

THE SCALE INSECTS OF CALIFORNIA

PART 2

THE MINOR FAMILIES

(Homoptera:Coccoidea)

MARGARODIDAE, ORTHEZIIDAE, KERRIIDAE, ASTEROLECANIIDAE,
LECANODIASPIDIDAE, CEROCOCCIDAE, ACLERDIDAE, KERMESIDAE,
DACTYLOPIIDAE, ERIOCOCCIDAE, AND PHOENICOCOCCIDAE

by:

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Associate Insect Biosystematist
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Sacramento, California, USA

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Funds for publication provided by the Pest Exclusion
and Nursery Programs Branch

1993

The color photograph on the front cover is of the cottony cushion scale, *Icerya purchasi* (Maskell), on *Grevillea* sp., taken X-4-79 in Capitol Park, Sacramento, Sacramento County, California.

**STATE OF CALIFORNIA
DEPARTMENT OF FOOD AND AGRICULTURE
DIVISION OF PLANT INDUSTRY**

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Dedicated to

Roma, Sheri and Susie

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PREFACE

The **Scale Insects** are a group of animals in the insect superfamily Coccoidea, which are in turn included in the insect order Homoptera. The Homoptera are separated from other groups of insects by Entomologists primarily because of piercing-sucking types of mouth parts situated near the posterior ventral part of the head. All of the Homoptera are plant feeders. Many are of economic concern to Agriculture in California and throughout the World. Scale insects are encountered daily by Field Entomologists, County Agricultural and Extension Personnel, University Researchers, Nurserymen, Quarantine Inspectors, Pest Control Advisors and many others. Unfortunately, comprehensive books on the habits and economic importance of these creatures are in short supply. Further, few if any of the scale insects are studied in University and College classes. Hopefully this book will fill some of these gaps.

This book is designed to be both a **field guide** and a **laboratory manual** for the minor (meaning composed of very few species) scale insect families of California. It is the second part of what is hoped will be a five volume set covering all of the Coccoidea and the Aleyrodidae (whiteflies) of California. The five volumes will be divided as follows: Part 1, "The Soft Scales" or Coccidae (already published); Part 2, "The Minor Families" covered here; Part 3, "The Armored Scales" or Diaspididae; Part 4, "The Mealybugs" or Pseudococcidae and Putoidae; and Part 5, "The Whiteflies" or Aleyrodidae. The volumes are not being produced in any particular phylogenetic order, but rather in the order of need by those field personnel and scientists dealing with scale insects on a day to day basis. The author's reasoning is that two of the three major families of the Coccoidea, the Diaspididae and the Pseudococcidae, have already been thoroughly treated in the two excellent works by Howard McKenzie. However, the soft scales had never been covered in a comprehensive fashion for California and their economic importance dictated that they should be given first priority. All of the remaining scale insect families (the minor families) likewise have never been treated comprehensively in California. Because of this and because of their lesser economic importance, the minor families are included in this volume.

While the whiteflies are not part of the same superfamily as the scale insects, their appearance and economic status are similar and they will be included in the fifth volume. Like the soft scales and the minor families, the whiteflies have never been treated comprehensively in the State. There has been much demand for such a treatise. However, the author wishes to postpone publication on the whiteflies of California, at least for a time, because there may be some important changes taking place in California and North American whitefly taxonomy and nomenclature in the next several years.

All of the proposed volumes are essentially written. All that remains is to find the necessary funds for publication and time for the physical typesetting and layout.

This volume is designed with the Field Entomologist and Agriculturalist in mind. Every California scale species is listed along with its approved or suggested common name, other historical common names, field characteristics, species which are similar and which are likely to be confused with it in the field, lists of common hosts, general distribution, and summaries

of its biology and economic importance. Selected references are provided at the end of each species treatise. Color photographs of all of the more economic species as well as photographs of some of the less important native or uncommon species are included.

The author has not attempted to give complete host and distributional records for several reasons. Primarily, the Entomology Laboratory Unit, Analysis and Identification Branch, of the California Department of Food and Agriculture, has not kept records of any insect collections or interceptions in any manner except chronological order. With the advent of new and superior computer equipment, it may now be possible to rectify that problem and to get complete host and distributional data for the scale insects. However, data entry will still require years of work and it was deemed more important to publish the volumes without this data in the interests of both time and expense.

Control measures are not included even though they are probably the first concern of the Field Entomologist. With the drastic changes in Pesticide Use Enforcement Regulations that have occurred over the last 10-15 years, the author is really not qualified to dispense such information. Also, several other very useful publications by other authors on the biologies and economic importance of horticultural pests have been removed from circulation because of changes in the legality of use of certain pesticides. It would be an obvious disaster to see this volume follow the same path. However, Biological Control, as it relates to Integrated Pest Management, is not affected by the same restrictions, and references to pertinent literature on natural enemies is included whenever available or appropriate.

For the Laboratory Scientist and Taxonomist, this volume represents a complete checklist and taxonomic treatment of eleven of the fifteen known California scale insect families. Complete, full scale taxonomic illustrations and keys to the genera and species are provided as well as a complete list of synonymies. The book is not, however, meant to be a taxonomic review or revision. There are no species descriptions or changes in synonymies included; they were deemed beyond the scope and general purpose of this book.

This book is meant to be complimentary to the Color and Host Identification Field Keys which are available through this author or the Environmental Monitoring and Pest Management Branch of the Department of Pesticide Regulations, Sacramento.

LIST OF COLOR PHOTOGRAPHS

1. captive pine scale, *Desmococcus captivus* McKenzie (adult females).
2. captive pine scale, *Desmococcus captivus* McKenzie (adult females).
3. cottony cushion scale, *Icerya purchasi* Maskell (nymphs).
4. cottony cushion scale, *Icerya purchasi* Maskell (adult with *Vedalia* ladybeetle).
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11. pinyon needle scale, *Matsucoccus acalyptus* McKenzie (adult female).
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13. one-needle pinyon scale, *Matsucoccus monophyllae* Morrison (cysts).
14. one-needle pinyon scale, *Matsucoccus monophyllae* Morrison (male).
15. one-needle pinyon scale, *Matsucoccus monophyllae* Morrison (adult female).
16. one-needle pinyon scale, *Matsucoccus monophyllae* Morrison (adult female in calling pose).
17. Deleon pinyon scale, *Pityococcus deleoni* McKenzie (adult females in situ., with lichens removed).
18. Deleon pinyon scale, *Pityococcus deleoni* McKenzie (adult female).
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20. a marsupial coccid, *Steatococcus* sp., (last stage nymph).
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22. sycamore scale, *Stomacoccus platani* Ferris, (adult male and female cyst).
23. sycamore scale, *Stomacoccus platani* Ferris (old injury and empty cysts).
24. birch margarodid, *Xylococcus betulae* (Pergande) (appearance of waxen extrusions).
25. birch margarodid, *Xylococcus betulae* (Pergande) (cysts).
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27. incense cedar scale, *Xylococcus macrocarpae* (Coleman) (cyst).
28. incense cedar scale, *Xylococcus macrocarpae* (Coleman) (pupa and males).
29. incense cedar scale, *Xylococcus macrocarpae* (Coleman) (mobile adult female).
30. incense cedar scale, *Xylococcus macrocarpae* (Coleman) (immobile ovipositing adult female).
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33. oak xylococcus scale, *Xylococcus quercus* (Ehrhorn) (mobile adult females).
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 50. least pit scale, *Asterolecanium minus* Lindinger (adult females).
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 58. chamise scale, *Lecanodiaspis rufescens* (Cockerell) (adult female, male puparium).
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 61. oak wax scale, *Cerococcus quercus* Comstock (adult females).
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94. pointed hair eriococcin, *Acanthococcus epacrotrichus* Miller & Miller (adult females).

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96. eriogonum eriococcin, *Acanthococcus eriogoni* Ehrhorn (adult female).
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101. European elm scale, *Gossyparia spurius* (Modeer) (adult male).
102. European elm scale, *Gossyparia spurius* (Modeer) (nymphs and male puparium).
103. European elm scale, *Gossyparia spurius* (Modeer) (adult females).
104. European elm scale, *Gossyparia spurius* (Modeer) (adult female).
105. eriogonum ovaticoccin, *Oregmomyia eriogoni* Miller (adult females).
106. neglected ovaticoccin, *Oregmomyia neglecta* Cockerell (adult females).
107. agave ovaticoccin, *Ovaticoccus agavium* (Douglas) (adult females).
108. red date scale, *Phoenicococcus marlatti* Cockerell (adult females).

ACKNOWLEDGEMENTS

Many people have played a significant role in the development of this manuscript, the already published Coccidae volume, and in the other three as yet unpublished volumes. First and foremost, the person most responsible for the production of this work is Richard F. Wilkey, formerly of this Department, who many years ago taught me how to prepare slide-mounted scale specimens, taught me the basics of scale insect identification and recommended me for my present scale insect taxonomist position in Sacramento. His beautiful slide preparations have been the models for most of the morphological drawings which will appear in three of the five volumes.

Thanks are due also to Tokuwo Kono, my former supervisor, for his help, consideration and support over the years, as well as for his beautiful photographs. Likewise for George Buxton, another former supervisor and friend, for his help, photography and for the fishing experiences that kept me from having to think about scale insects all of the time. Thanks also to former Riverside County Agricultural Commissioner Robert Howie and to Robert Davis, also formerly with that Department, for giving me my start in Agricultural Entomology and for their help and training in Plant Quarantine.

Of course, the people who actually did all of the work really deserve all of the credit. Thanks first to Robin Breckenridge, who courageously deciphered my handwritten notes and typed the first draft of all five volumes. Robin—I couldn't have done it without you. Thanks next to Susan Kaiser, whose expertise with telegraphic writing styles and abbreviated bibliographical citations were a God-send. I was never able to write in anything except a complete sentence! Thanks next to Susan Sawyer, who did the proofing after I couldn't stand to look at it any longer. Special thanks are due to Brenda Beckwith, who pasted up the artwork and photocopied and proofed the final 5 or 20 copies of the last few revisions before a final copy finally went to the printer. Thanks are due also to Maria Alexander and Lily Malare, who worked on various versions of the manuscript and/or the illustrations.

Thanks are due to Fred Andrews for the use of his computer and scanner and to Dennis Mayhew and John Sorensen for their expertise with computer modems, which together allowed the transfer of the Vydec manuscript to my personal computer.

The manuscript has been edited by a number of very competent reviewers and their help and suggestions are deeply appreciated. Steve Nakahara (USDA, SEL) thoroughly edited the first draft and made countless useful suggestions. Douglass R. Miller, Dr. Michael Kosztarab, Dr. Charles Ray and Dr. Steven Bullington have all reviewed and supplied keys to species for the various family chapters. Robert Dowell and John Sorensen also made many suggestions and found innumerable small errors and inconsistencies. If there are any spelling errors and other minor imperfections still left after their thorough review, I will be very much surprised. Robert Dowell was also the major impetus behind the scale insect and whitefly color and host field keys mentioned elsewhere in this volume. Charles Papp, formerly of this Department, was responsible for getting this project started initially and showed me how to work with color separations. I also wish to thank John Sorensen for introducing me to the computer used in this work and for teaching me about hanging paragraphs and tab indents. Thanks to Darvin DeShazer for the introduction to the page-layout software.

And last but not least, thanks for the money, Don.

INTRODUCTION

Scale insects (including mealybugs) comprise the superfamily Coccoidea in the order Homoptera. About 5000 species of Coccoidea have been described, and about 20% of them occur in the United States. The group contains much variation and includes minute and highly specialized forms. All scale insects which possess legs have 1 or 2-segmented tarsi, bearing a single claw. The antennae are 1-13 segmented. Females are always apterous, but adult males may be apterous or winged. When winged, they possess only 1 pair. Adult males have no functional mouthparts. Eggs are usually deposited beneath the female or in a waxy ovisac. First instars (crawlers) have functional legs and are mobile, but later instars including adults may or may not have legs. Adult females and immature stages of both sexes feed on plants by inserting their long stylets into a part of the host and sucking out its juices.

The families of scale insects which are considered to be most primitive are sometimes referred to as the **Archaeococcoidea**. Adult females of these families usually possess abdominal spiracles, and adult males often have faceted eyes. Representatives of two of these families, the Margarodidae and Ortheziidae, are found in the United States.

The families of scale insects which are considered to be the most advanced are referred to as the **Neococcoidea**. The adult females do not have abdominal spiracles, and the adult males all have simple eyes. Representatives in 14 of these families are found in the United States. Notes on each family are followed by selected references in the individual sections of this book for the reader who desires additional information. *Uncited references (such as original species descriptions) can found in one of the following bibliographies: Morrison & Renk (1957), all references through 1955; Morrison & Morrison (1965), from 1956-63; Russell, et al. (1974), from 1964-69 or Kosztarab & Kosztarab, through 1988. All others are found in References Cited at the end of each section and in the 'Bibliography' on pages 218-226 .*

The following key can be used to distinguish the families of scale insects of California based on the morphology of adult females. It is adapted from the key to the families of scale insects of America north of Mexico by Howell & Williams (1976).

KEY TO THE CALIFORNIA FAMILIES OF SCALE INSECTS (BASED ON ADULT FEMALES)

1. Abdominal spiracles present (Fig. 1, 2) (ARCHAEOCOCOIDEA) 2
- Abdominal spiracles absent (NEOCOCOIDEA) 3
2. Anal ring distinct, with numerous pores and 6 long setae (Fig. 1); antennae 3-8 segmented (Fig. 1) **Ortheziidae**
- Anal ring reduced, with no pores or setae; eyes rarely stalked; antennae 1-13 segmented (Fig. 2) **Margarodidae**

- 3. A large dorsal spine present near center of abdomen (Fig. 3); anterior spiracles much larger than posterior; brachial plates present on dorsum near spiracles **Kerriidae**
— No large dorsal spine near center of abdomen; spiracles about equal in size; brachial plates absent **4**

- 4. Anal opening covered with 2 triangular anal plates which form an operculum (Fig. 4) (except in the genus *Physokermes*); abdomen with a well-developed anal cleft (**covered in Part 1, the soft scales of California**) **Coccidae**
— Never more than 1 anal plate (operculum) covering anal opening (though sclerotized plates laterad of anal opening may be present as in Fig. 9); anal cleft, if present, usually not as well-developed as in Fig. 4 **5**

- 5. A triangular or oval anal plate covering anal opening (Fig. 5); furrows or ridges present on caudal margin; usually found under leaf sheaths of grasses **Aclerididae**
— No anal plate covering anal opening; furrows or ridges not present on caudal margin; habitat variable **6**

- 6. 8-shaped pores present on dorsum (Fig. 7, 8, 9) **7**
— 8-shaped pores absent from dorsum; 8-shaped tubular ducts (Fig. 13) rare, when present derm always with small irregularities (Fig. 13) **10**

- 7. 8-shaped pores on dorsum and in a submarginal band on venter; ventral tubular ducts scattered over body; antennae 1-9 segmented; on various hosts **8**
— 8-shaped pores restricted to dorsum; ventral tubular ducts forming a submarginal band around body; antennae 5-segmented; on oaks (Fig. 6) (in part) **Kermesidae**

- 8. Antennae 1-9 segmented; ventral bilocular pores (Figs. 8, 9) and sclerotized anal plate present **9**
— Antennae 1-segmented; ventral bilocular pores and sclerotized anal plate absent (Fig. 7) **Asterolecaniidae**

- 9. Antennae 1-segmented, with an associated cluster of 5-7 locular pores; sclerotized plate lying over anal opening, triangular-shaped (Fig. 8) **Cerococcidae**
— Antennae 7-9 segmented; without an associated cluster of 5-7 locular pores; sclerotized plate lying over anal opening not triangular-shaped, much wider than long (Fig. 9) **Lecanodiaspididae**

- 10. 3,4, and 5 locular pores usually in clusters, with a common duct (Fig. 10), scattered over dorsum; numerous, thick, truncate setae on body; anal opening usually appears as a transverse slit; on Cactaceae **Dactylopiidae**
— Pores not arranged as above; setae usually not truncate, though sometimes blunt; anal opening variable; on various hosts **11**

- 11. Abdomen terminating in a compound pygidium or pygidium-like area (Figs. 11, 12); anal opening simple; body covered by a secreted thin shield-like scale **12**
— Abdomen without posterior segments fused to form a pygidium contrasting with anterior

- segments of the abdomen; anal opening often setiferous; body not covered by thin shield-like scale. 13
12. Beak 1-segmented; legs usually absent or reduced to remnants; antennae 1-segmented (Fig. 11A); multilocular pores absent; pygidium (Fig. 11A,B) formed of the fused terminal abdominal segments, contrasting with the anterior segments of the abdomen; dorsal ocellar eyespots absent; scale covering constructed around the 1st molted skin (**not covered in this volume**). **Diaspididae**
- Beak 2-segmented; legs present; antennae 3 or 4 segmented; multilocular pores present; pygidial segments less completely fused (Fig. 12); dorsal ocellar eyespots present; scale covering not containing the exuviae of the earlier molts (Fig. 11C) (**not established in California**). **Conchaspidae**
13. Small irregularities present on derm (Fig. 13); legs absent; 8-shaped tubular ducts (Fig. 13) occurring on dorsum and venter (very small and hard to see without high power magnification); anal ring simple, with 0-2 setae and no pores; often associated with palms **Phoenicococcidae**
- Dermal irregularities absent; legs usually present; 8-shaped tubular ducts absent; anal ring variable. 14
14. Dorsal ostioles, ventral circuli, and trilocular pores (Fig. 14, 15) usually present; usually with 1-18 pair of cerarii (Fig. 14, 15); anal ring with inner and outer layers of pores; tubular ducts not invaginated. 15
- Without dorsal ostioles, cerarii, circuli and trilocular pores; invaginated tubular ducts present (Fig. 16, 17); anal ring variable. 16
15. Cerarii of adult females usually numbering 18 and consisting of 6-20 or more enlarged, apically pointed setae set on large, heavily sclerotized plates; adult males with 5-7 pairs of simple eyes (**not covered in this volume**). **Putoidae**
- Cerarii of adult female may number 18 but usually less, and only rarely with all cerarii with 6-20 setae set on heavily sclerotized plates; adult males with 3 pairs of simple eyes (**not covered in this volume**). **Pseudococcidae**
16. Tubular ducts, when present, scattered over venter of body; anal ring usually with pores and setae; microtubular ducts present; usually with protruding anal lobes (Figs. 16, 17) **Eriococcidae**
- Tubular ducts arranged in a ventral submarginal band (Fig. 6); anal ring simple, without pores and setae; microtubular ducts absent; without distinctly protruding anal lobes; usually associated with oaks. **Kermesidae**

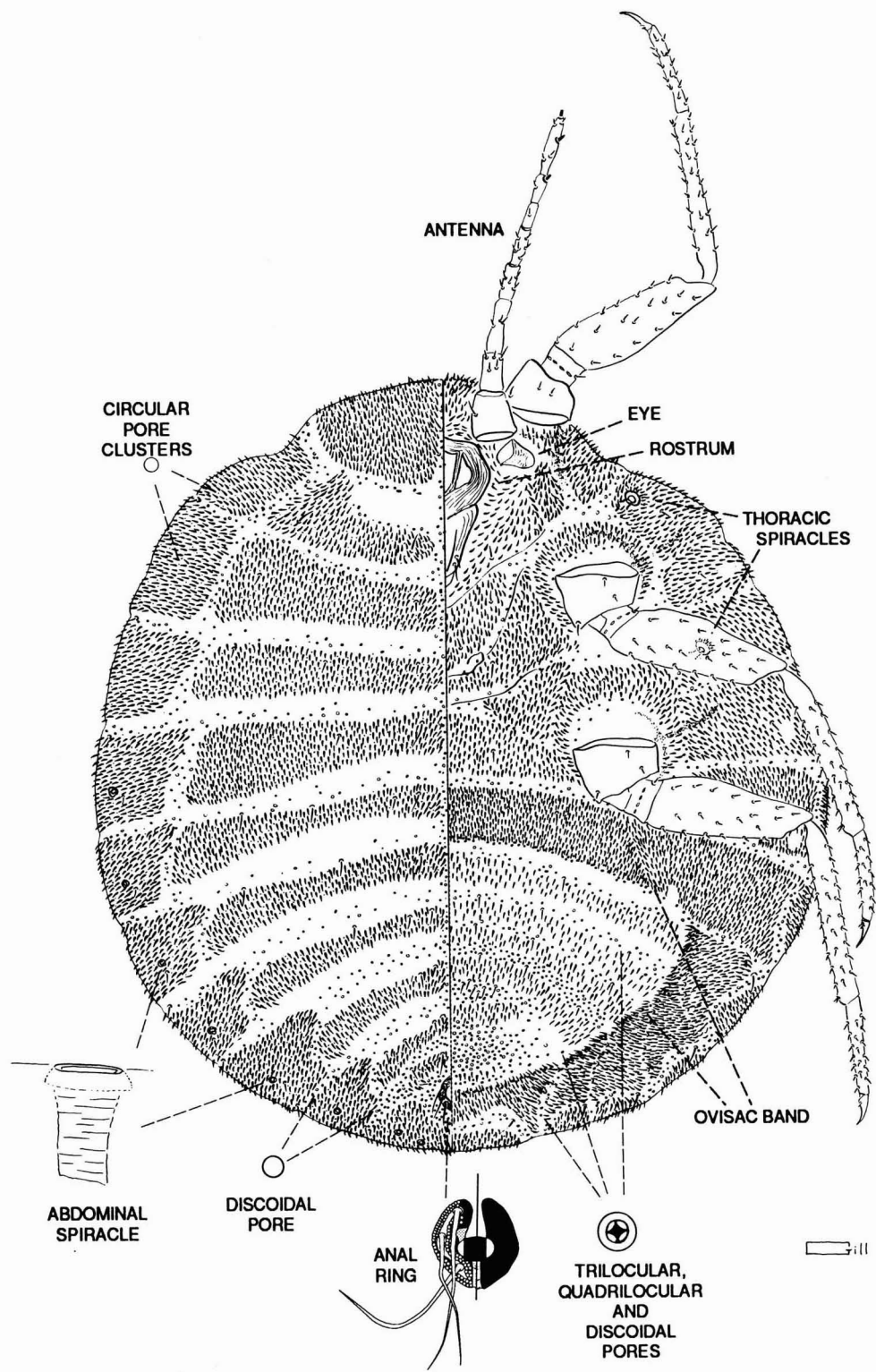
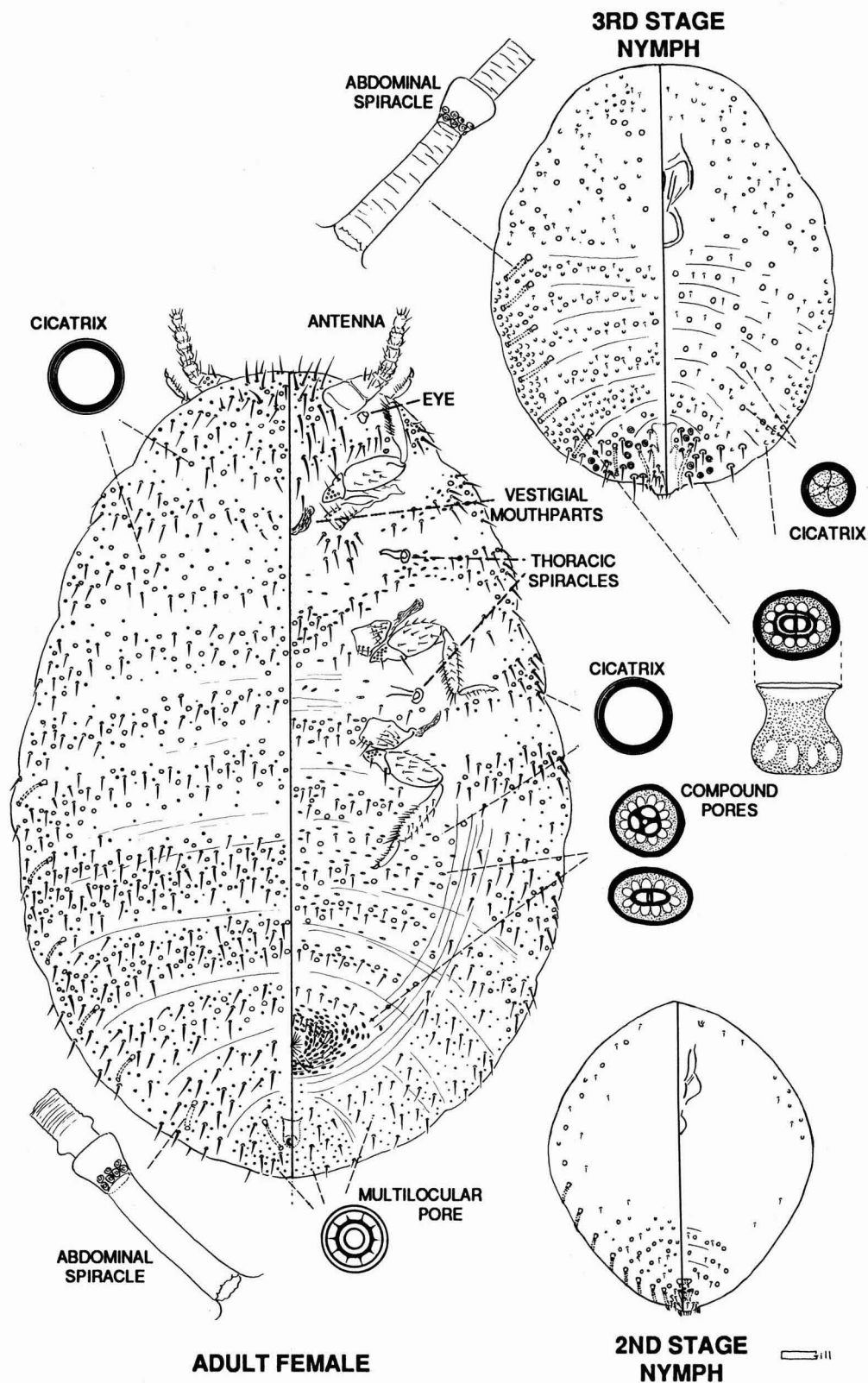


Fig. 1: Morphology of the family Ortheziidae



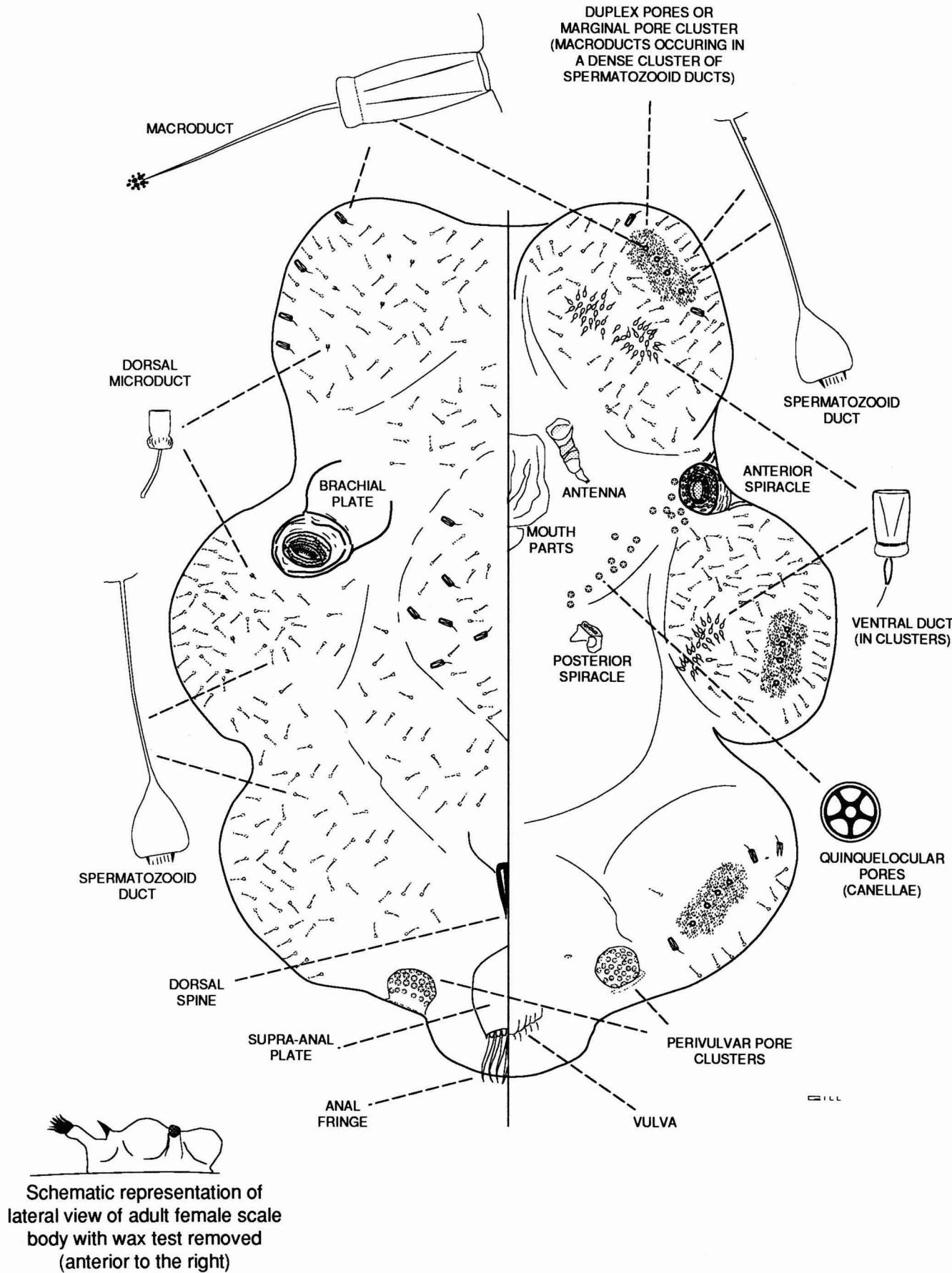


Fig. 3: Morphology of the family Kerriidae

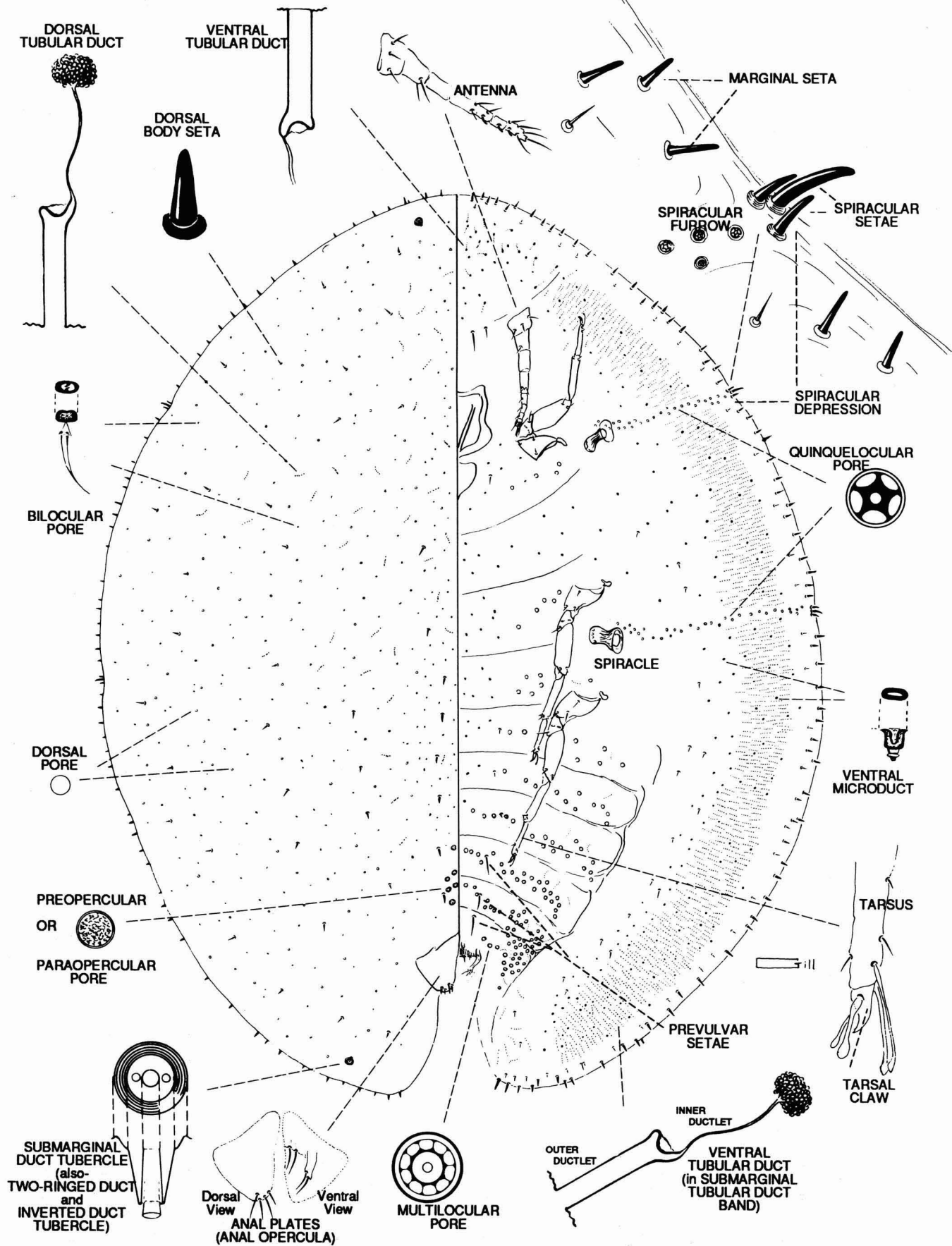


Fig. 4: Morphology of the family Coccidae

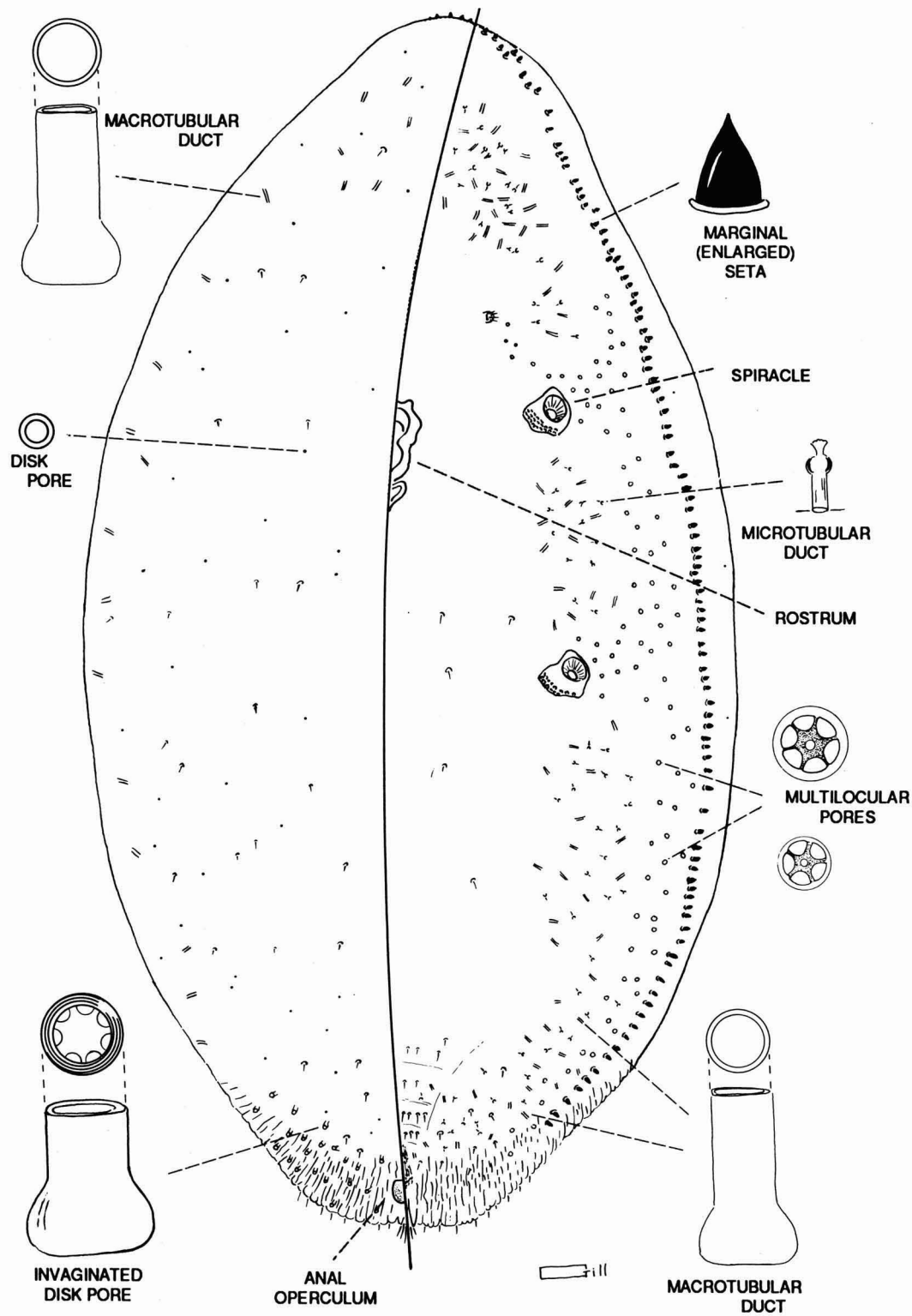


Fig. 5: Morphology of the family Acleridae

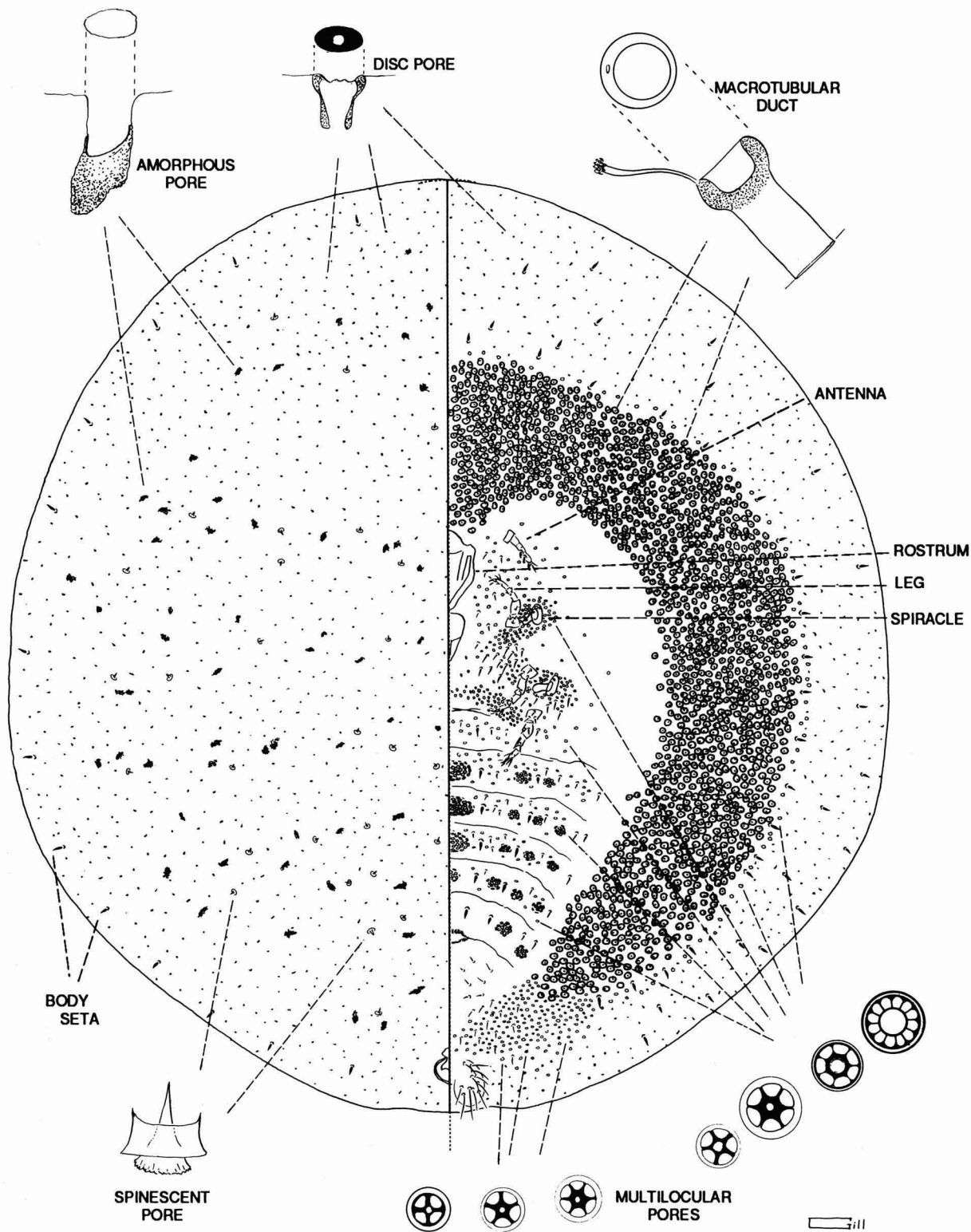


Fig. 6: Morphology of the family Kermesidae

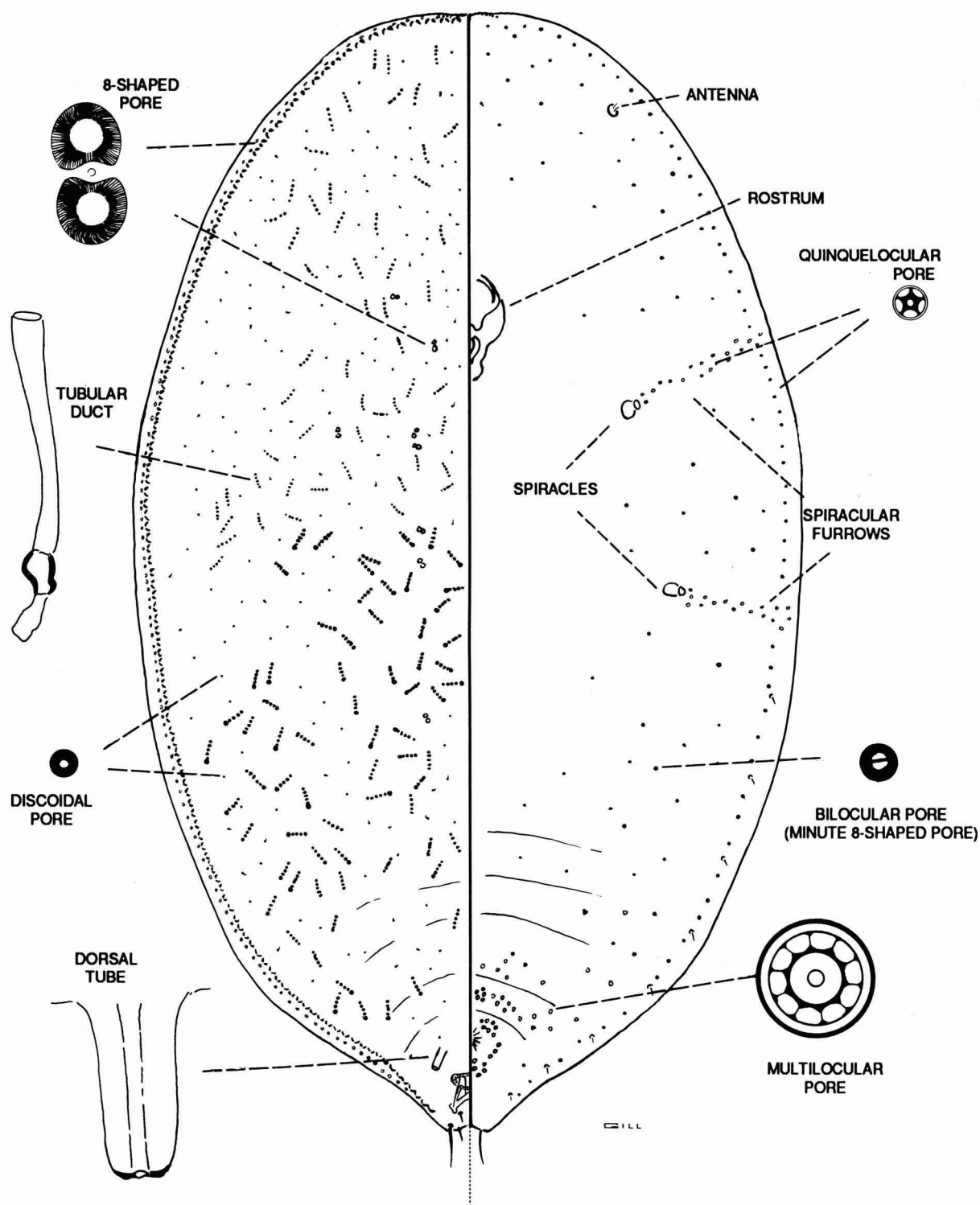


Fig. 7: Morphology of the family Asterolecaniidae

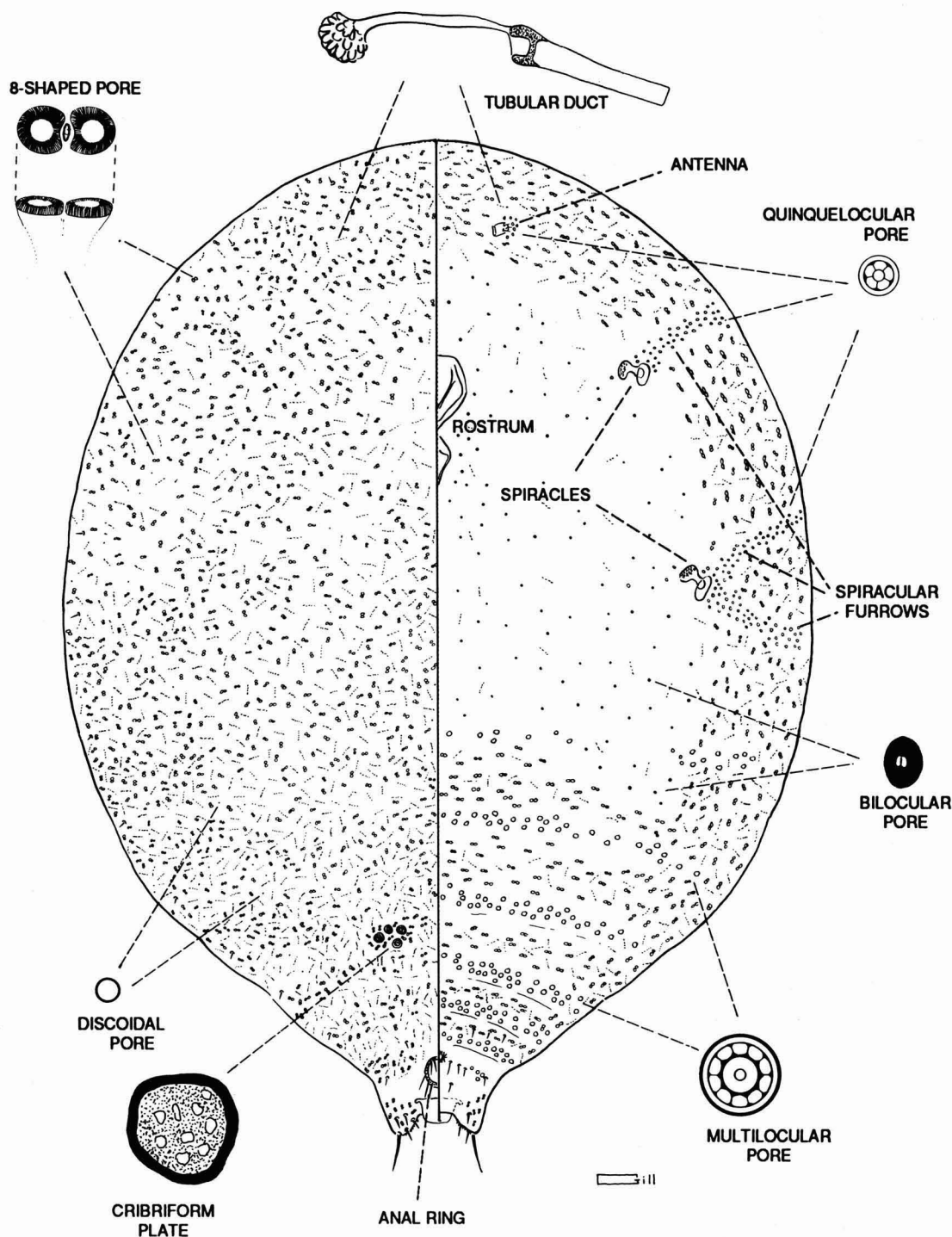


Fig. 8: Morphology of the family Cerococcidae

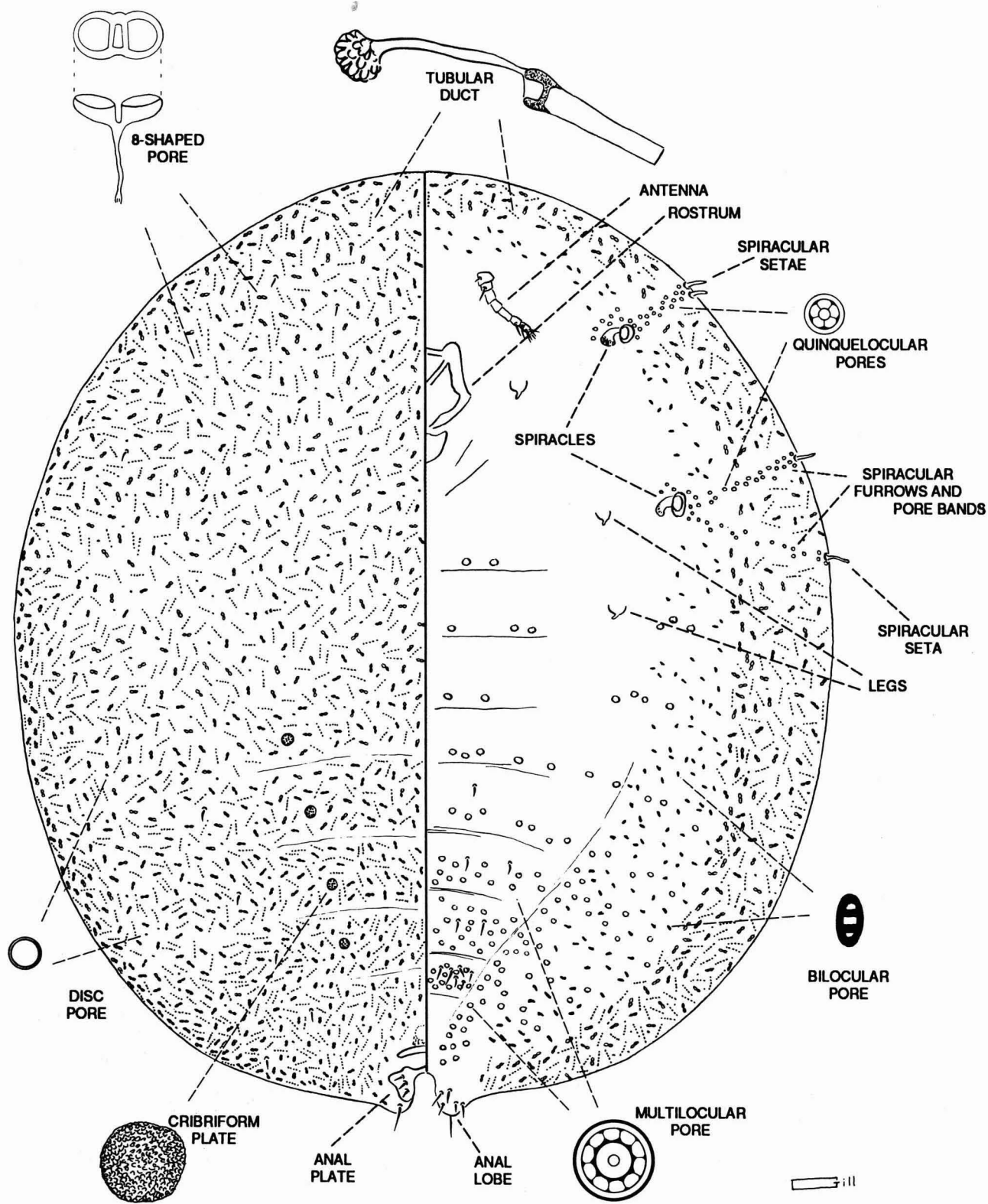


Fig. 9: Morphology of the family Lecanodiaspididae

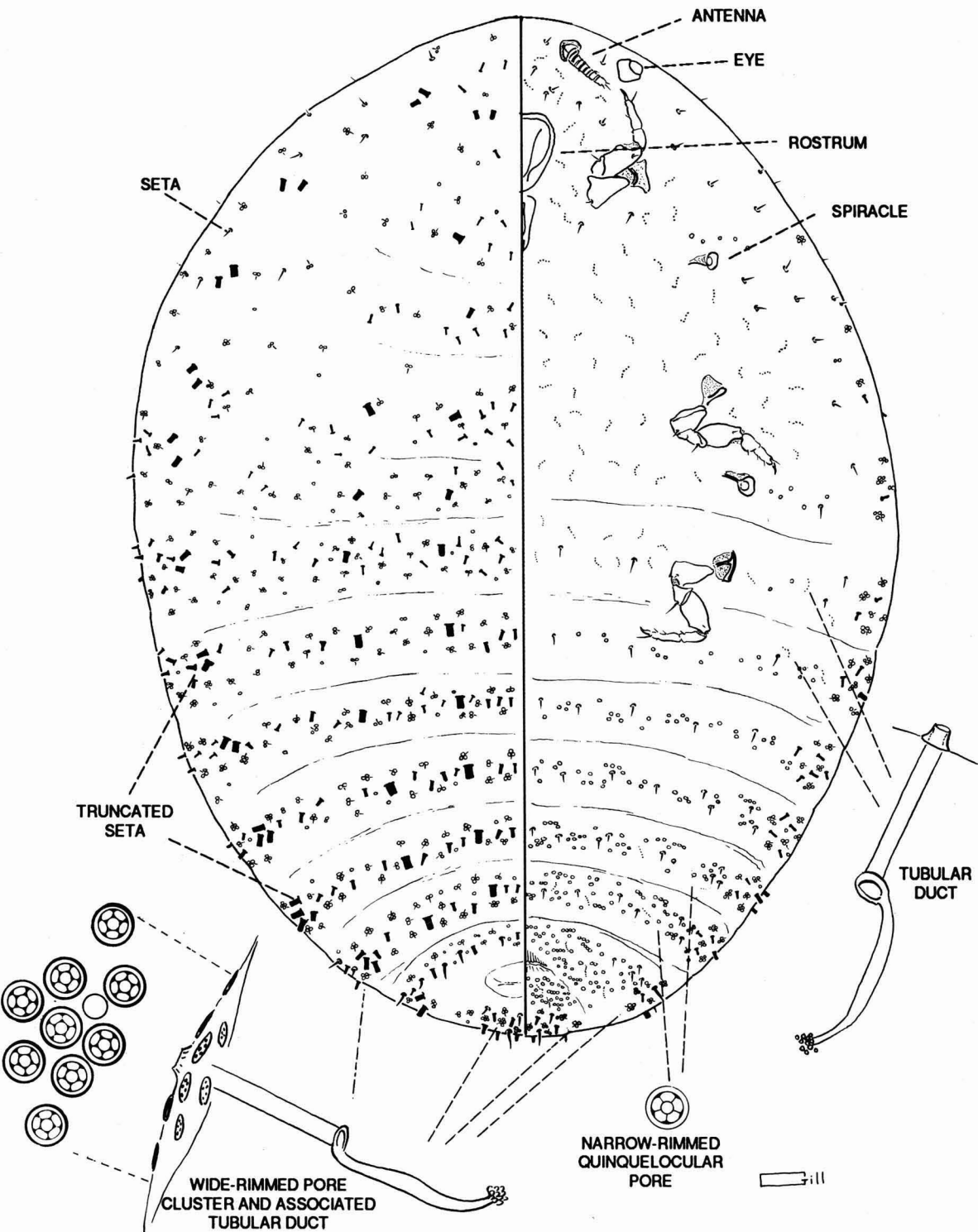
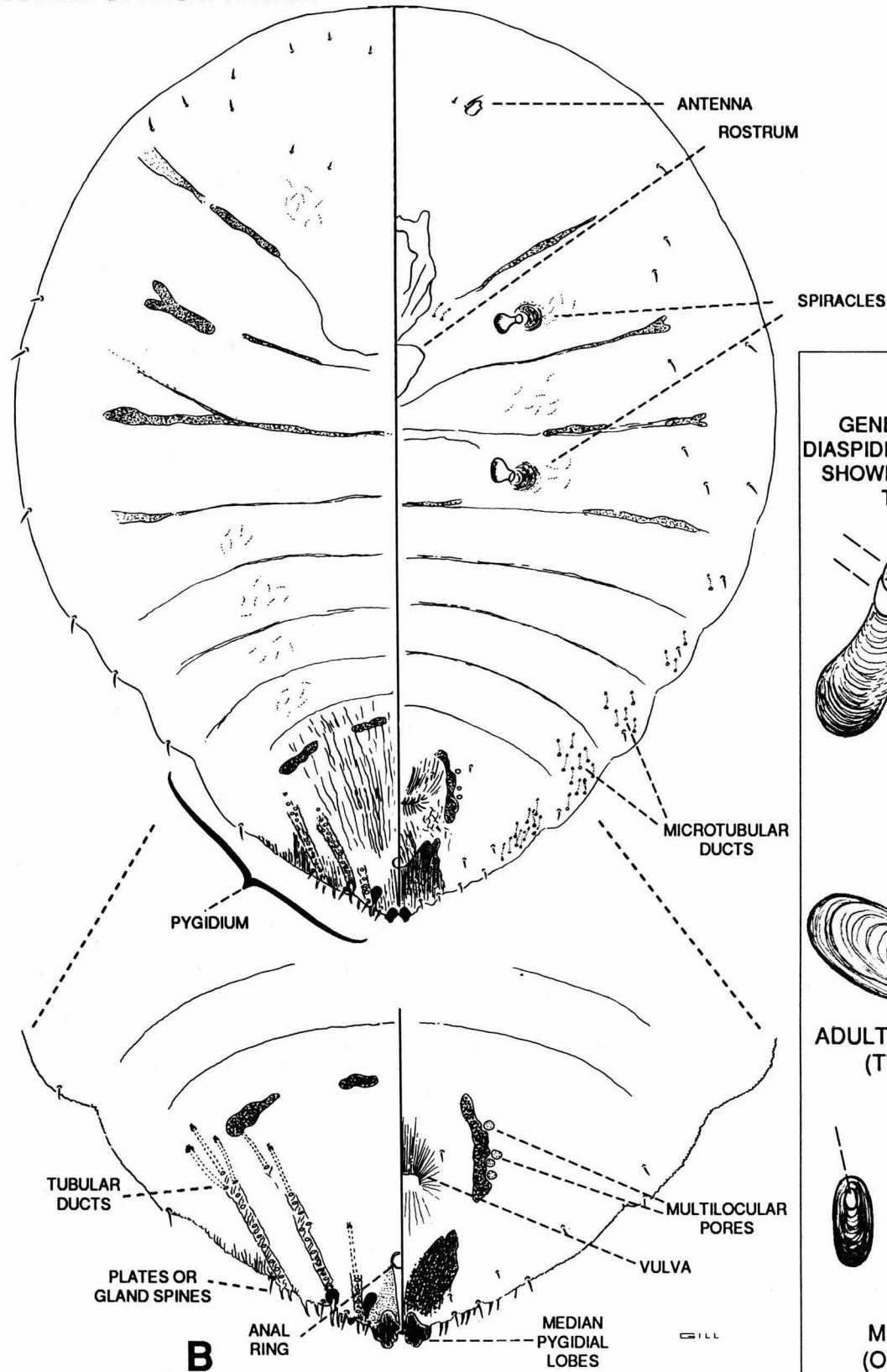


Fig. 10: Morphology of the family Dactylopiidae

A
OUTLINE OF ADULT FEMALE



B
PYGIDIUM AREA ENLARGED

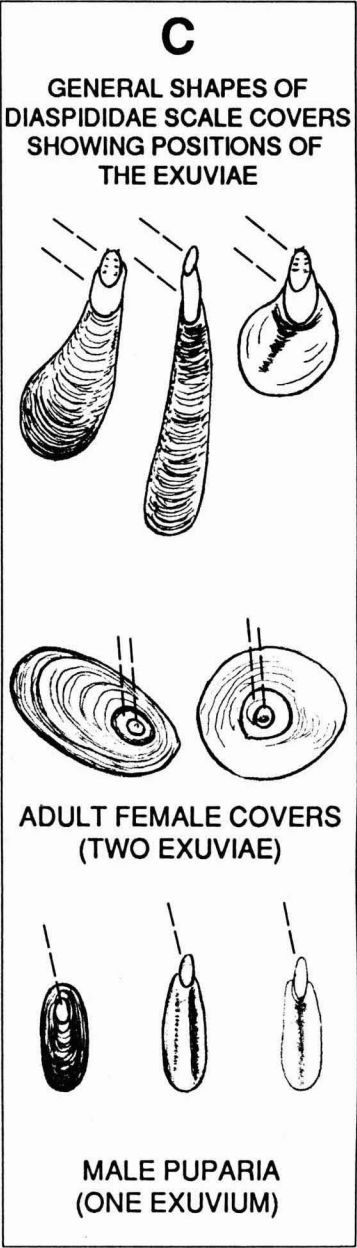


Fig. 11: Morphology of the family Diaspididae

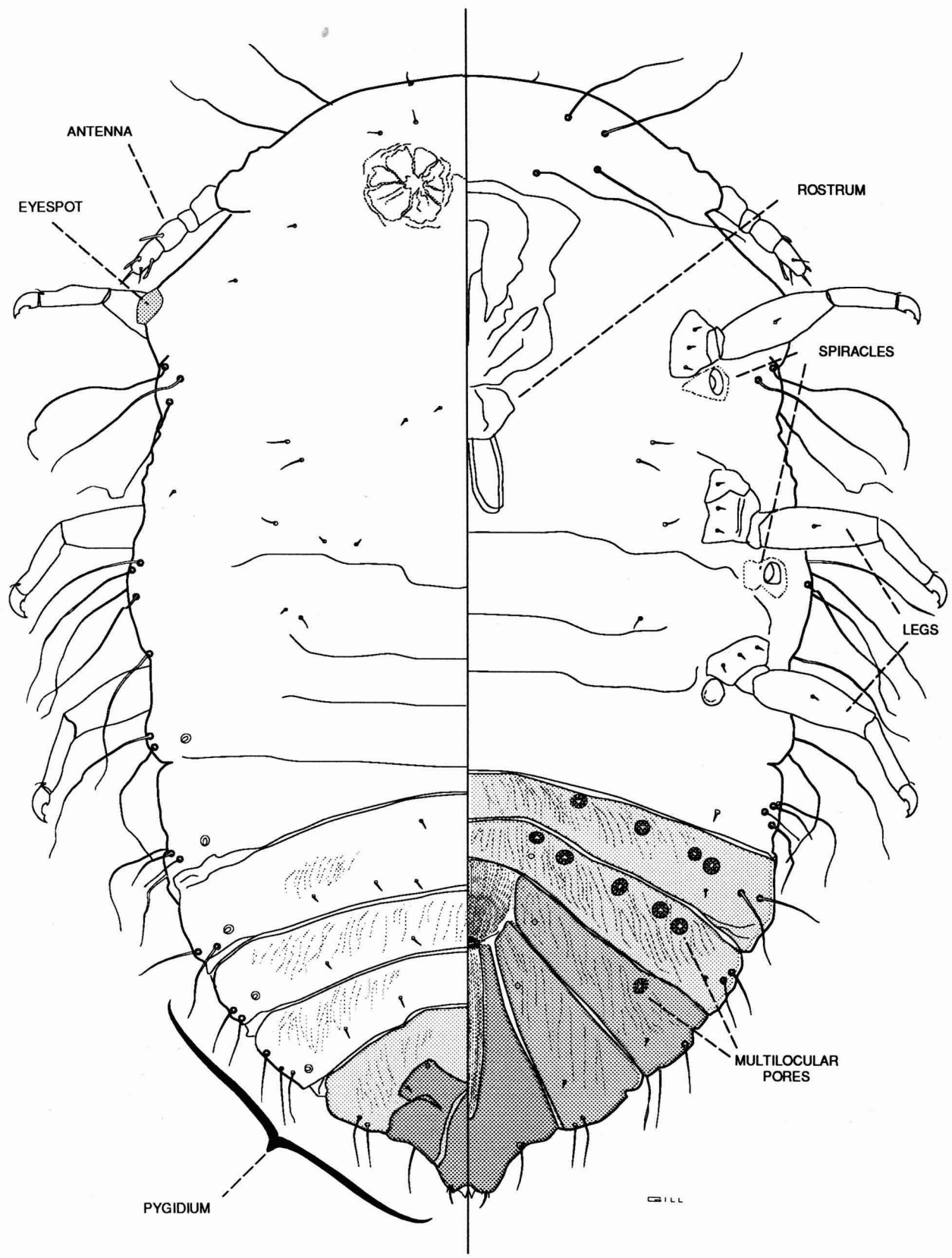


Fig. 12: Morphology of the family Conchaspididae

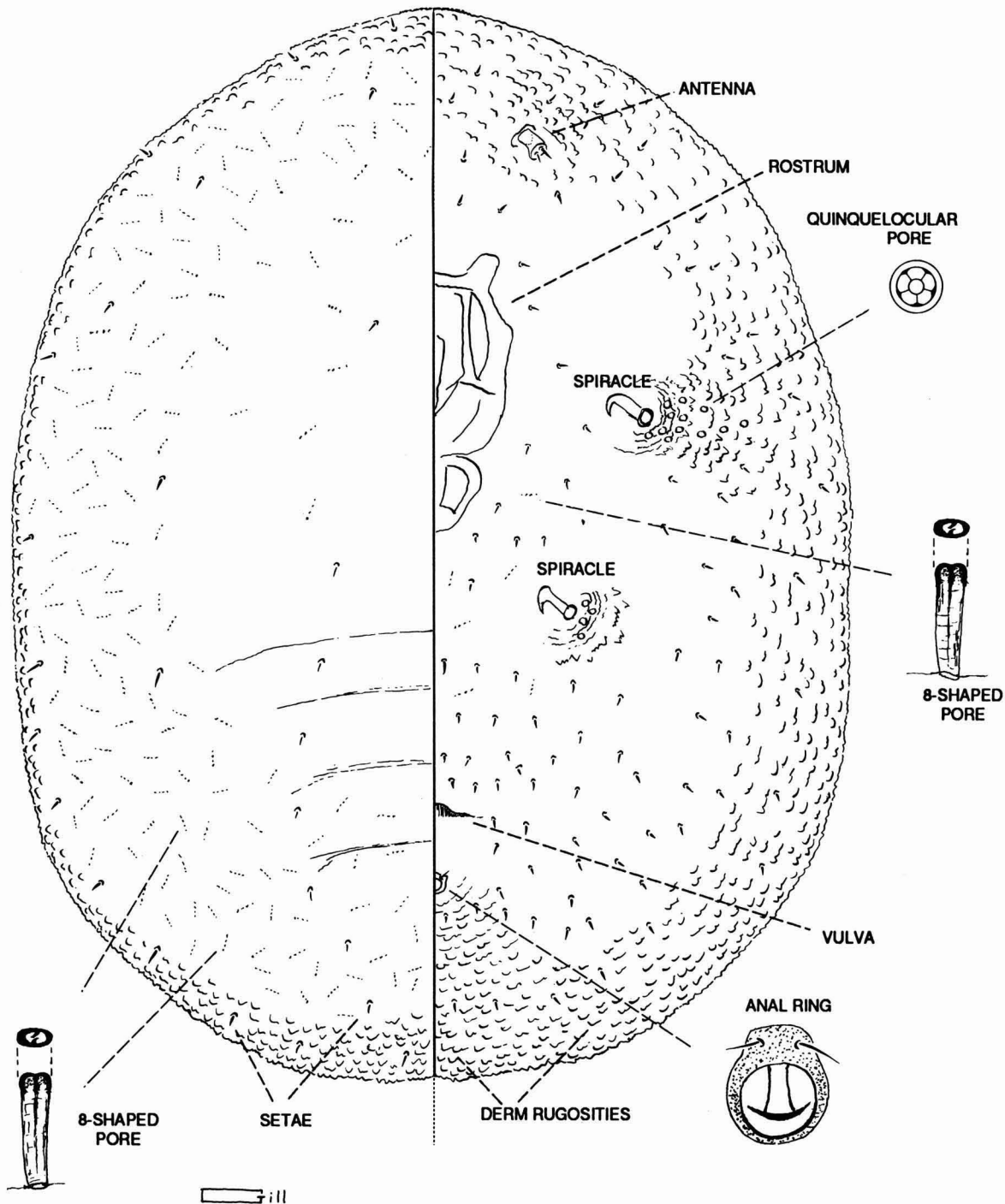


Fig. 13: Morphology of the family Phoenicococcidae

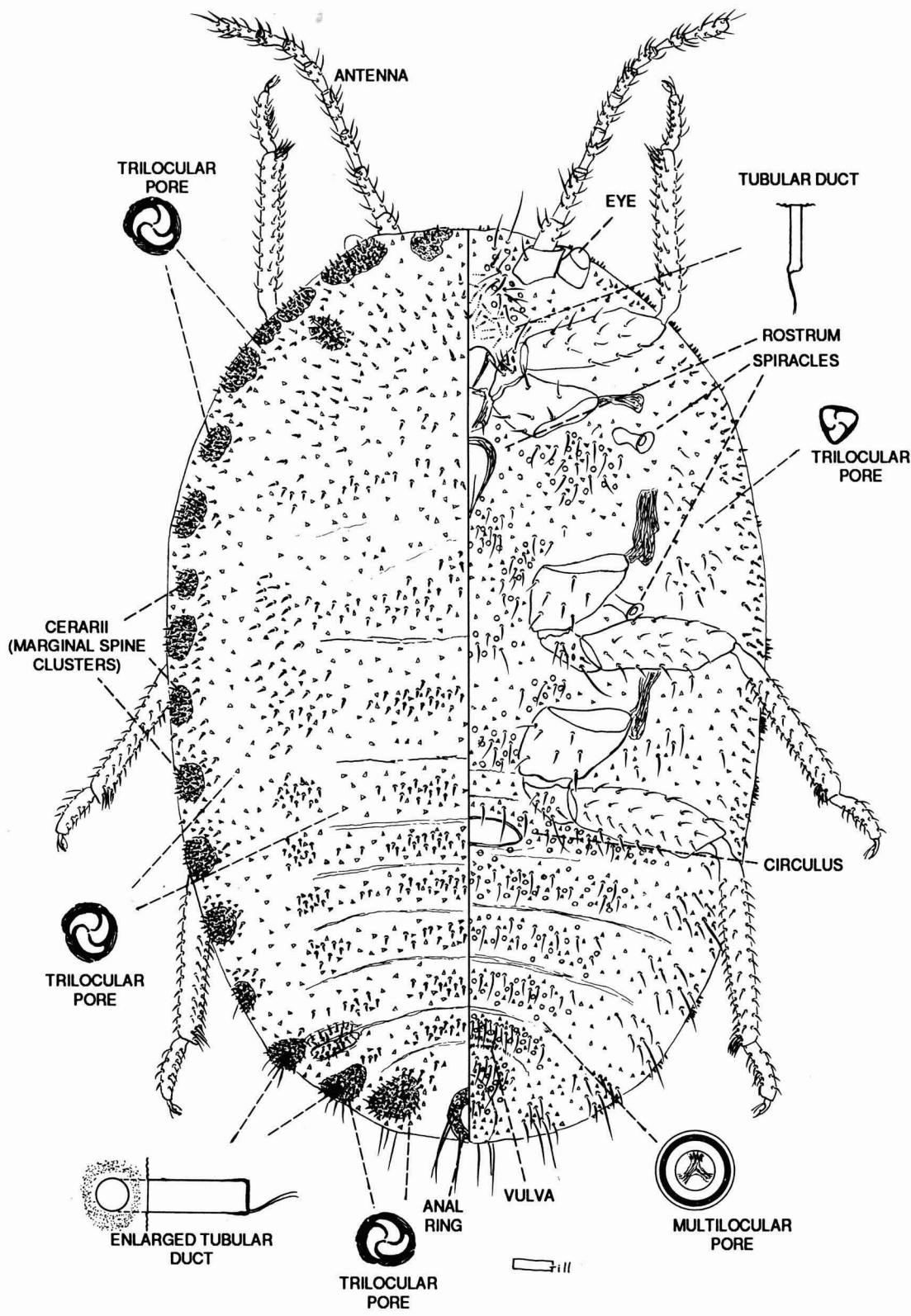


Fig. 14: Morphology of the family Putoidae

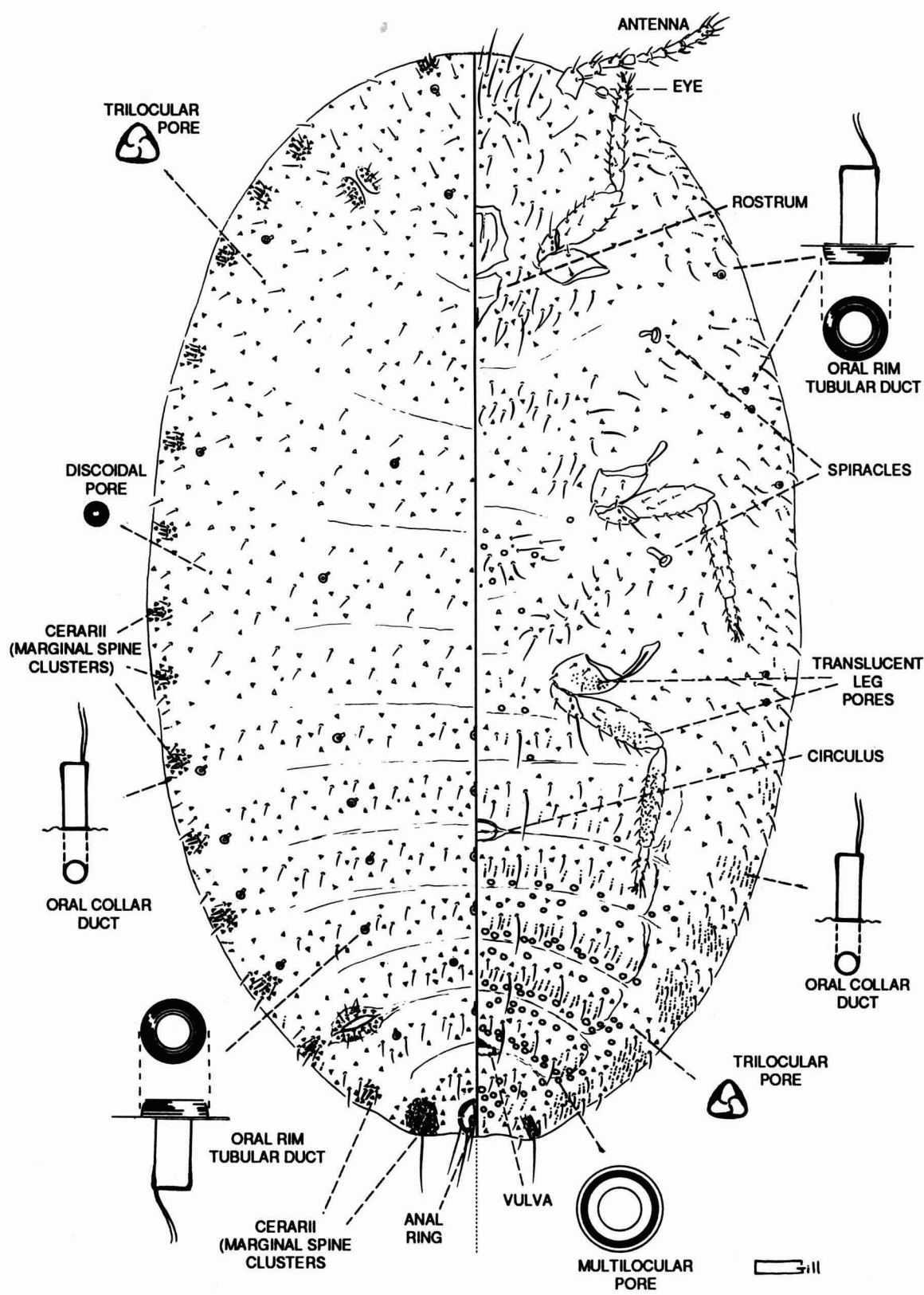


Fig. 15: Morphology of the family Pseudococcidae

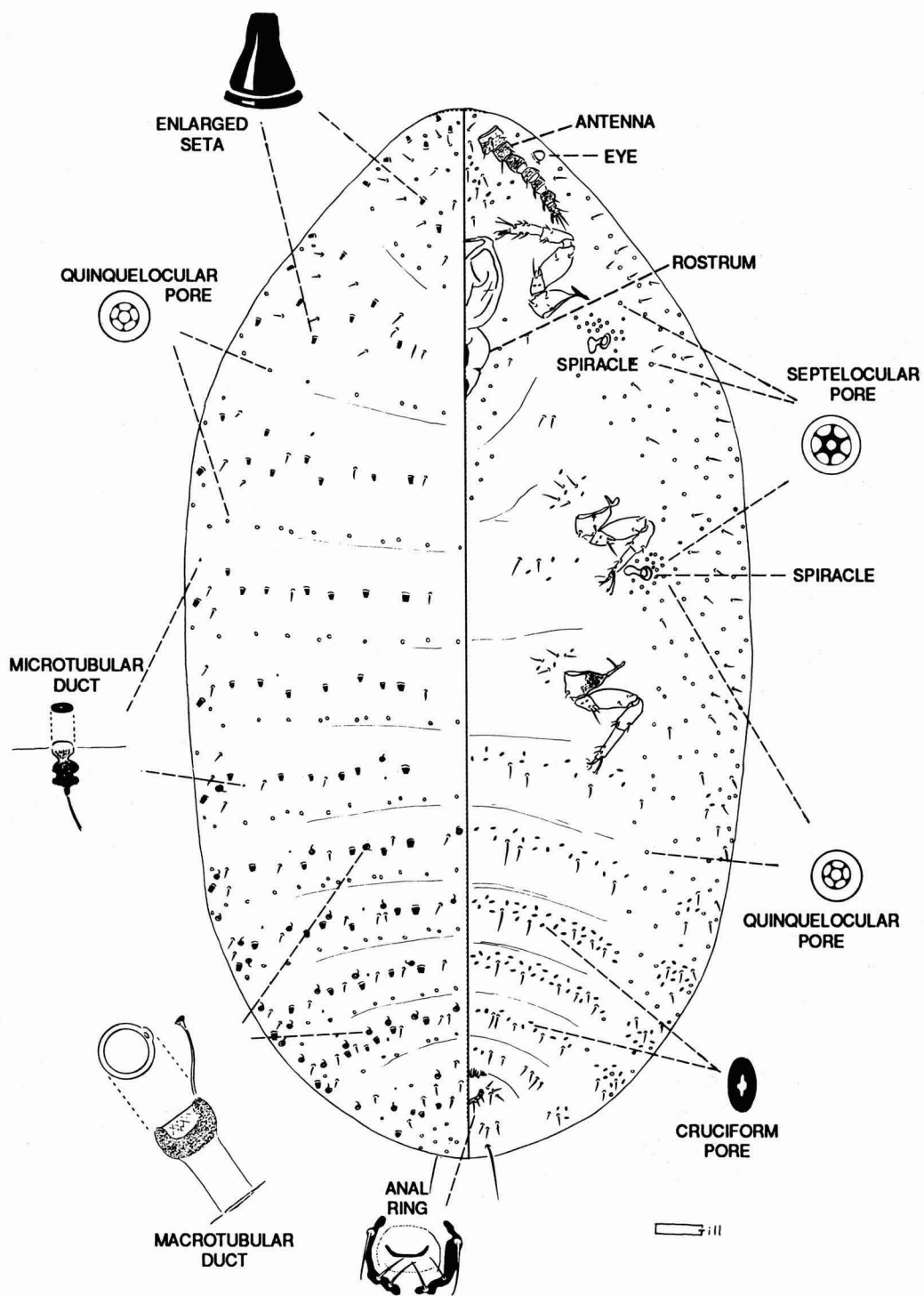


Fig. 16: Morphology of the "ovaticoccin type" of the family Eriococcidae

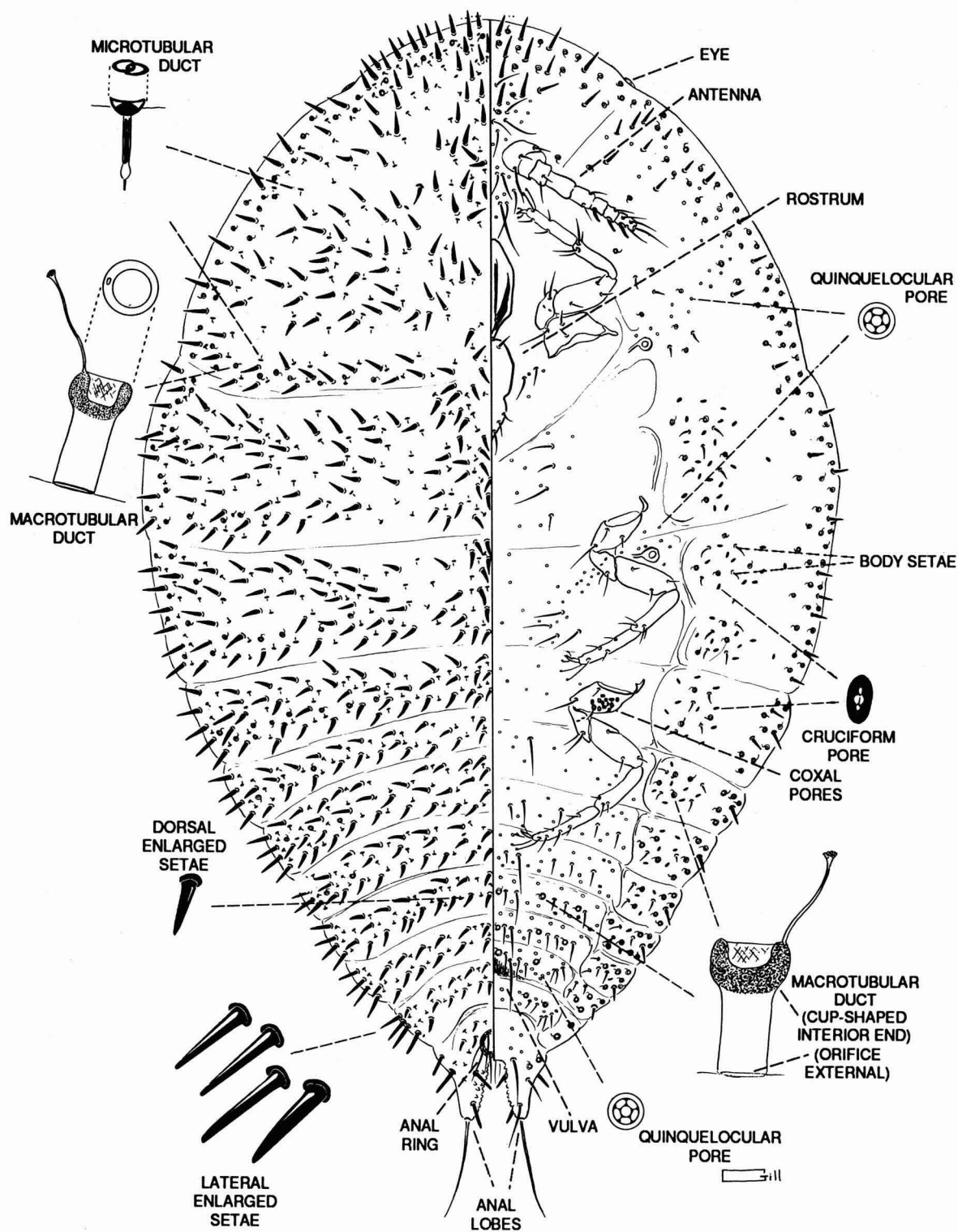


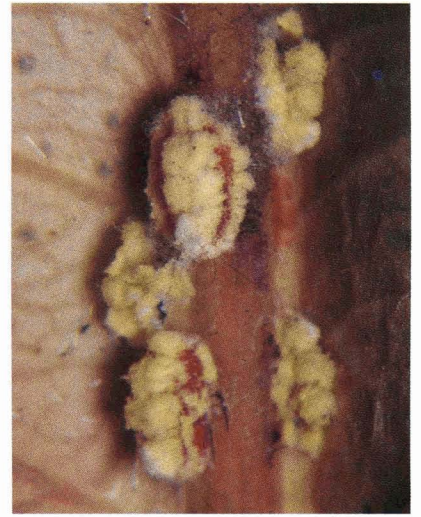
Fig. 17: Morphology of the "eriococcin type" of the family Eriococcidae



1. *Desmococcus captivus* adults



2. *Desmococcus captivus* adults



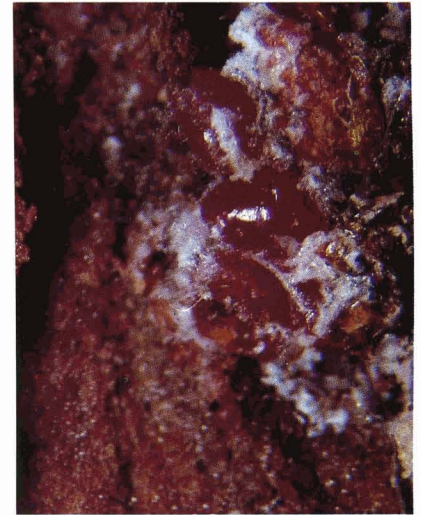
3. *Icerya purchasi* nymphs



4. *Icerya purchasi* and *Vedalia*



5. *I. purchasi* and *Cryptochetum*



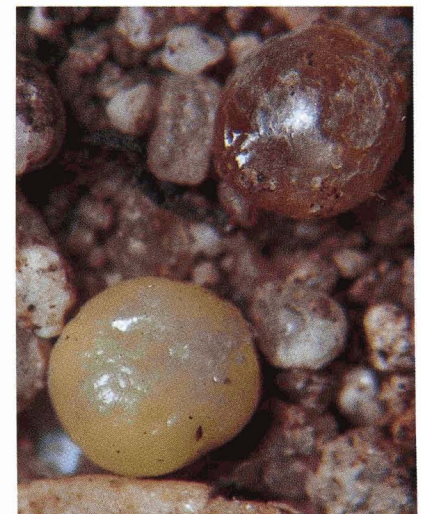
6. *Kuwania quercus* cysts



7. *Kuwania quercus* adult



8. *Margarodes heimalis?* adult



9. *Margarodes meridionalis* cysts



10. *Matsucoccus acalyptus* cysts



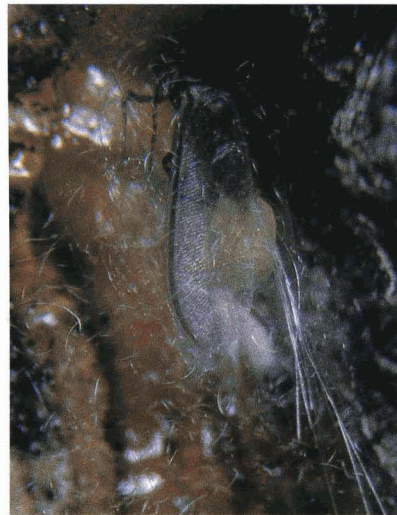
11. *Matsucoccus acalyptus* adult



12. *Matsucoccus fasciculensis* cysts



13. *Matsucoccus monophyllae* cysts



14. *Matsucoccus monophyllae* male



15. *Matsucoccus monophyllae* adult



16. *M. monophyllae* adult calling



17. *Pityococcus deleoni*



18. *Pityococcus deleoni* adult



19. *Steatococcus* sp.



20. *Steatococcus* sp.



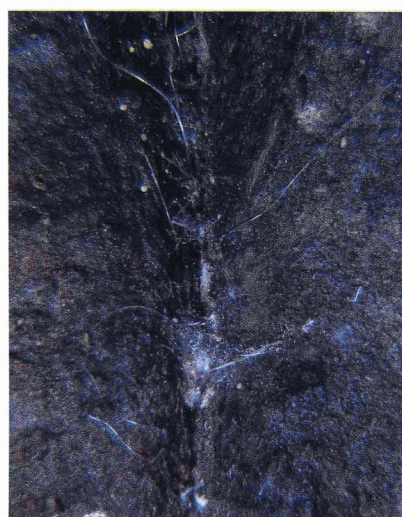
21. *Stomacoccus platani* adult



22. *S. platani* adult male and cyst



23. *Stomacoccus platani* old injury



24. *Xylococcus betulae* wax tubes



25. *Xylococcus betulae* cysts



26. *Xylococcus macrocarpae* cysts



27. *Xylococcus macrocarpae* cysts



28. *X. macrocarpae* pupa & males



29. *X. macrocarpae* mobile adult



30. *X. macrocarpae* 'ovisac'



31. *Xylococculus quercus* wax tubes



32. *Xylococculus quercus* cyst



33. *Xylococculus quercus* adults



34. *Arctorthezia occidentalis*



35. *Orthezia annae*



36. *Orthezia annae*



37. *Orthezia artemisiae*



38. *Orthezia artemisiae*



39. *Orthezia insignis*



40. *O. newcomeri* male & female



41. *Orthezia newcomeri*



42. *Orthezia sarcobati*



43. *Tachardiella ferrisi*



44. *Tachardiella larreae*



45. *Tachardiella pustulata*



46. *Asterolecanium agavis*



47. *Asterolecanium arabidis*



48. *Asterolecanium arabidis* pits



49. *A. arabidis* twig distortion



50. *Asterolecanium minus*



51. *Asterolecanium stentae*



52. *Asterolecanium variolosum*



53. *Bambusaspis bambusae*



54. *Mycetococcus ehrhorni*



55. *Pollinia pollini*



56. *Pollinia pollini*



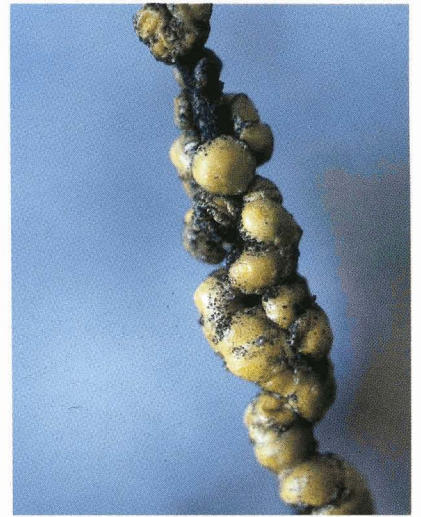
57. *Lecanodiaspis rufescens*



58. *Lecanodiaspis rufescens*



59. *Lecanodiaspis thamnasmae*



60. *Cerococcus quercus*



61. *Cerococcus quercus*



62. *Aclerda californica*



63. *Aclerda* sp.



64. *Aclerda tokionis*



65. *Allokermes branigani*



66. *A. essigi* young females



67. *A. essigi* male puparium



68. *Allokermes essigi*



69. *A. essigi* old females



70. *Allokermes ferrisi*



71. "*Eriococcus*" *gilletti*



72. *Kermes nudus*



73. *Kermes rimarum*



74. *Kermes shastensis*



75. *Dactylopius confusus*



76. *Dactylopius confusus*



77. *Dactylopius opuntiae*



78. *Dactylopius tomentosus*



79. *Dactylopius tomentosus*



80. *Acanthococcus adenostomae*



81. *Acanthococcus araucariae*



82. *Acanthococcus araucariae*



83. *Acanthococcus azaleae*



84. *Acanthococcus azaleae*



85. "*Eriococcus*" *borealis*



86. "*Eriococcus*" *borealis*



87. *Acanthococcus coccineus*



88. *Acanthococcus coccineus* ovisac



89. *Acanthococcus cryptus*



90. *Acanthococcus diaboli*



91. *Acanthococcus diaboli* ovisacs



92. *Acanthococcus dubius*



93. *Acanthococcus dubius*



94. *Acanthococcus epacrotichus*



95. *Acanthococcus epacrotichus*



96. *Acanthococcus eriogoni*



97. *Acanthococcus eriogoni* ovisac



98. *Acanthococcus quercus*



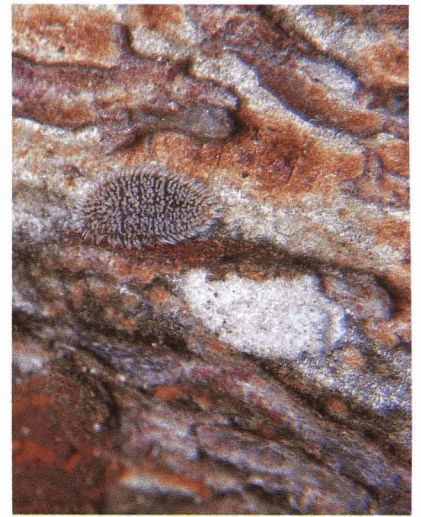
99. *Acanthococcus quercus*



100. *Gossyparia spuria* male puparia



101. *Gossyparia spuria* male



102. *G. spuria* nymphs, puparia



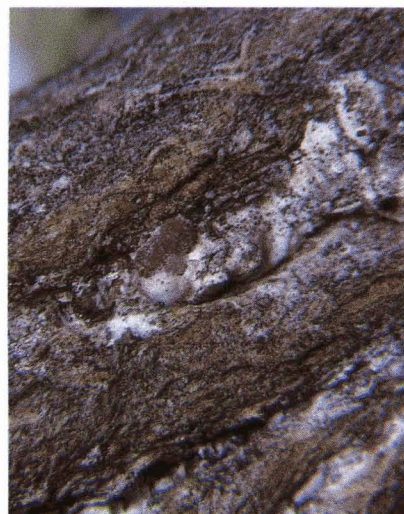
103. *Gossyparia spuria* females



104. *Gossyparia spuria* female



105. *Oregmopyga eriogoni*



106. *Oregmopyga neglecta*



107. *Ovaticoccus agavium*



108. *Phoenicococcus marlatti*

FAMILY MARGARODIDAE

margarodids, giant scales and ground pearls
Color Plates 1-33

The family Margarodidae is a small family represented world-wide by diverse and hard-to-characterize groups of scale insects. Several subfamilies contain forms which have legs in the first instar larvae, then lose their legs in subsequent instars, only to have them reappear in the adult stage. In the subfamily Monophlebinae, however, all instars usually have legs. Some groups form legless cysts in immature stages (ground pearls) which may survive for almost 20 years under adverse conditions. Species in the genus *Steatococcus* are unusual in that the center of the abdomen of the adult female invaginates to form a marsupial-like pouch for protection of the eggs. Other subfamilies are referred to as giant coccids. For example, in the Central American genus *Llaveia*, individuals may reach well over 1/2 inch in length and 3/8 inch in thickness. For more information on habits and distribution of margarodids, see Morrison (1928).

Field Characteristics: This family contains a number of diverse forms. Field appearance and other data for California species are included in the discussions of individual species. Some species are easily recognized in the field and may be identified with the aid of the following field key:

Field Key to California Margarodidae

- (a) On conifers
 - (b) On trunk and branches of incense cedar, particularly in shaded locations *Xylococcus macrocarpae*
 - (b₁) Under bark, in bark cracks, or at bases of needles of pines *Matsucoccus, Pityococcus, Desmococcus*
- (a₁) On hosts other than conifers
 - (b) All stages subterranean *Margarodes* spp.
 - (b₁) On aerial parts of plants, only occasionally on roots (*Steatococcus*)
 - (c) Extremely tiny, causing necrotic spots on leaves of sycamore *Stomacoccus platani*
 - (c₁) Large species; not on sycamore
 - (d) Large species on subtropical hosts; red body, black appendages, yellow wax and white fluted egg sac *Icerya purchasi*
 - (d₁) On deciduous hardwoods such as oak and alder . . . *Xylococcus* spp.
 - (d₂) On desert shrubs; may have red body, black appendages, and yellow wax, but no white ovisac *Steatococcus* spp.
 - (c₂) Small red species under bark of oak *Kuwania quercus*

Biology: Most species feed on stems and branches of the host; a few feed on leaves or roots.
Similar Species: Ortheziids are very similar to margarodids. Some mealybugs and eriococcids superficially resemble margarodids.

Hosts: The family as a whole is not restricted to a particular plant group.

Economic Importance: Only four or five genera contain species of economic concern, but some species are capable of causing serious injury to cultivated plants. See individual accounts of *Icerya purchasi* and *Margarodes meridionalis*.

Distribution: Worldwide.

Diagnosis: The family has been thoroughly studied by Morrison (1928). It is characterized by the presence of abdominal spiracles and a simple anal ring without pores or setae. Morrison provides excellent keys to the subfamilies, genera, and species. California species are fairly distinct and identifications can be made in most cases by studying the accompanying illustrations and the Diagnosis sections. For the large genus *Matsucoccus*, a key is provided by Charles Ray.

Most taxonomic keys to the scale insects are based on the adult female stages because these stages contain most of the diagnostic characteristics which allow separation of the forms. In these situations, it is usually a simple matter to distinguish between an immature or an adult stage because of the presence of the vulva (or opening of the oviduct); in many cases by the presence or absence of multilocular pores containing more than 5 loculi; and by the presence of wings and an aedeagus in the male stages. Only occasionally are other stages such as crawlers or adult males used for specific, generic, or higher category separations. In the Margarodidae, however, the vulva is difficult or impossible to locate in some species and the immatures of many species have multilocular pores. Also, there are such drastic differences between the stages that it is extremely difficult to determine immediately the actual stage present. For these reasons the following key will not be based solely on the adult female stages.

References:
Morrison, H., 1928: U.S. Dep. Agric. Tech. Bull. 52:1-239.

KEYS TO SUBFAMILIES, TRIBES AND GENERA OF CALIFORNIA
MARGARODIDAE

(ADULT FEMALES AND SOME EARLIER INSTARS)

1.

Legs and antennae greatly reduced or absent, if present then represented only by one segment (appearing as low protuberance with associated sensory setae); normally under bark of trees or subterranean— usually immature instars or cyst forms with one exception

2
- Legs and antennae normal, or if reduced, with some segmentation

7
2.

Atrium of thoracic spiracles with associated pores

3
- Atrium of thoracic spiracles without associated pores

4
3.

Anal tube simple, lightly sclerotized, reticulate; under bark of *Pinus monophylla* in Great Basin habitats; with clusters of thick-walled multilocular pores near most spiracles only; adult female with vulva apparent and with simple multilocular pores scattered randomly in vulvar region

Desmococcus
- Anal tube complex, heavily sclerotized and associated closely with last pair of abdominal

- spiracles; on other conifers and deciduous trees in most of California; with thick-walled multilocular pores randomly scattered, numerous; vulva absent immature *Xylococcus*
4. Multilocular and discoidal pores present; body bright crimson; under bark of Fagaceae immature *Kuwania*
- Multilocular and discoidal pores usually absent; body yellow, brown or reddish brown, never bright crimson; on other hosts or subterranean 5
5. Subterranean; body white or yellow *Margarodes*
- Inhabiting trees, usually under bark; body yellow or reddish 6
6. Under bark or on needles of pines (*Pinus*); body red or brown *Matsucoccus*
- Under bark or lower leaf surfaces of sycamore (*Platanus*); body yellow . . *Stomacoccus*
7. Tarsi distinctly two-segmented; disk-like simple pores present [*Xylococcinae*] 8
- Tarsi one-segmented, legs, if reduced, with some segmentation; disk-like simple pores wanting 9
8. Thoracic spiracles with or without bar, this usually not strongly developed, and with pores within atrium; abdominal spiracles with pores within atrium; abdominal spiracles definitely larger than thoracic; anal tube usually distinctly developed, quite evident *Xylococcus*
- Thoracic spiracles without bar, without pores within atrium; abdominal spiracles without pores within atrium; abdominal spiracles definitely smaller than thoracic; anal tube very poorly developed, hardly or not at all evident *Matsucoccus*
9. Atrium of thoracic spiracles without multilocular disk pores 10
- Atrium of thoracic spiracles with multilocular disk pores 13
10. Large multilocular pores (7 to 12 loculae, central area of pore bilocular) and long body setae numerous, randomly positioned; anal tube usually well developed, moderately sclerotized and usually with a well defined ring at outer end; ventral cicatrices present, usually with a total of three arranged transversely, the centermost cicatrix largest; adult individuals of relatively large size (4 to 20 mm) [*Monophlebinae*] 11
- Anal tube or anal ring poorly developed or wanting; cicatrices if present aligned longitudinally, centrally; adult individuals usually smaller than 4 mm 12
11. Eggs incubated in a white, posterior, waxen ovisac, ovisac produced by older, egg laying females only (absent until just prior to egg laying) *Icerya*
- Eggs incubated in a definite internal pouch (marsupium) at maturity; marsupium connected with the exterior through a large circular midventral opening, marsupial opening apparent in adult females of all ages *Steatococcus*
12. Claw with several (6 to 12) large, knobbed digitules surpassing apex of claw; under bark or lower leaf surfaces of sycamore (*Platanus*); body yellow [*Steingeliinae*]

- *Stomacoccus*
- Claw usually with 2 digitules, these knobbed and surpassing the claw apex, or short and not attaining claw apex, if with more than 2 then these short, acute, not at all conspicuous; ventral, apical areas of tibiae with capitate setae [Kuwaniiini] *Kuwania*
- 13. Anterior legs much enlarged, fitted for digging (coxa and tarsal claw much enlarged); subterranean on roots of many hosts [Margarodinae] *Margarodes*
- Anterior legs normal or similar in size to posterior pairs; known only from bark of shrubs and trees *Pityococcus*

THE CALIFORNIA SPECIES OF MARGARODIDAE

Genus *Desmococcus* McKenzie, 1942

Number of world species: 2.
Number of United States species: 2.
Key to the species: McKenzie, H. L., 1942: Microentomol. 7(1):1-18.

Desmococcus captivus McKenzie, 1942
captive pine scale

Fig. 18, Color Plate 1-2

<p>Field Characteristics: Adult females ovoid to round, 1.5 to 2.5 mm; nymphs round, 0.75 to 1.0 mm. All stages found within waxen cells beneath bark of branches and trunk.</p> <p>Similar Species: <i>Desmococcus sedentarius</i> McKenzie is very similar, but thus far is known only from Arizona. In habits and appearance, this species is also similar to other pine margarodids in the genera <i>Matsucoccus</i> and <i>Pityococcus</i>.</p> <p>Hosts: <i>Pinus monophylla</i>.</p> <p>Economic Importance: Presently unknown.</p>	<p>Distribution: Known only from two collection sites—one at Mono Lake, Mono County, and one at Westgard Pass, Inyo County.</p> <p>Diagnosis: Recognized by the lack of legs, presence of disk-like cicatrices on the ventral median areas of the abdominal segments, and by the presence of seven-lobed stellate pores on the abdomen (Fig. 5-8). For more information, see McKenzie (1942).</p> <hr/> <p>McKenzie, H. L., 1942: Microentomol. 7(1):1-18.</p>
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Genus *Icerya* Signoret, 1875

<p>Number of world species: About 40.</p> <p>Number of United States species: 2.</p> <p>Key to the species: Morrison, H., 1928: U.S.</p>	<p>Dep. Agric. Tech. Bull. 52:1-239. See also: Rao, V. P., 1951a and b: Indian J. Entomol. 12:39-66 and 127-158.</p>
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***Icerya purchasi* Maskell, 1879**
cottonycushion scale (ESA approved)

Fig. 19, Color Plate 3-5, Front Cover

Other Common Names:

fluted scale, citrus fluted scale, white scale, Australian bug.

Synonymy:

Pericerya purchasi (Maskell).

Field Characteristics: Length of adults with ovisac (egg sac) fully developed 10 to 15 mm. Most easily recognized when the white ovisac is present, but even if the ovasac has not been formed, the species should not be mistaken for any other scale insect in the field, even in the nymphal stages. The following characteristics distinguish this species (see Plates 3-5 and front cover):

- (a) The white ovisac is fluted, with a series of uniform ridges running lengthwise over the dorsal-posterior surface.
- (b) Body color of all stages is red, with conspicuous black appendages and long black setae (hairs). Wax secretions pale cream to lemon-yellow. Early nymphs largely covered with yellow wax, while adults and late nymphs retain only a narrow median band and interrupted marginal patches of yellow wax.
- (c) Adults have tufts of short black setae around the body margins.
- (d) All stages produce long, hair-like, transparent rods of wax similar to those produced by many soft scales.

Biology: About three generations per year; each individual can lay up to 1,000 eggs. For further information, see Anonymous (1889), Hale (1970a, 1970b) and Ormerod (1887). This scale is a hermaphroditic insect. Further information on hermaphroditism in the genus can be obtained from Hughes-Schrader

(1930).

Similar Species: Soft scales in the genus *Pulvinaria* produce a white ovisac similar to that of cottonycushion scale, but it is never uniformly ridged. Immatures and young adults of cottonycushion scale are often mistaken for mealybugs. However, only two species of mealybugs produce cream-colored or yellowish wax. These mealybugs do not have a red body, lack the conspicuous black appendages which are so readily seen in cottonycushion scale, and do not produce long, crystalline wax rods. *Icerya rileyi* Cockerell is a similar North American species known from Mexico, Texas, New Mexico, Utah and Arizona, which may also occur in the southeast corner of California. It differs from *I. purchasi* in that it has irregular clumps of dorsal wax, an unfluted ovisac and transverse streaks of yellow. Scales in the Ortheziidae have fluted ovisacs, but the wax plates are not uniformly ridged and the body color is not red.

Hosts: The most common hosts in California are *Citrus* and *Pittosporum*. However, the number of other hosts attacked appears endless. For more information, see Merrill (1953), Essig (1958), and Riddick (1955).

Economic Importance: After its initial introduction into California about 1868, cottonycushion scale became such a serious pest that it nearly brought an end to citrus fruit production in this state. Its introduction was a major force behind the development of our present biological control practices, our plant quarantine system, and the use of oil sprays for insect control. Two natural enemies—the now famous vedalia ladybird beetle, *Rodolia cardinalis* (Mulsant), and the cryptochetum fly, *Cryptochetum iceryae* (Williston), were introduced by Albert Koebele in 1888. These natural enemies now effect adequate control

of cottonycushion scale in most situations, except where pesticides are injudiciously used. Injury results in defoliation, fruit drop, and the formation of honeydew and sooty mold. For further information on the history and economic importance of this species, see Gossard (1901), Essig (1931), Quayle (1938), Zimmerman (1948), Ebeling (1959), Quezada & DeBach (1973) and Caltagirone & Doutt (1989).

Distribution: Throughout California at lower elevations. Rarely found on native hosts in uncultivated situations. Found outdoors in coastal and southern states, in greenhouses in others. Known from most tropical and subtropical areas of the world. Native to Australia.

Diagnosis: The shape of the ovisac, dorsal wax patterns, black tufts of hair on the abdominal margin and body color separate this species from all others. However, a line drawing of the morphology is provided (Fig. 19) to further aid in recognition. A thorough morphological study has recently been done by Howell & Beshear (1981).

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Genus *Kuwanina* Cockerell, 1903

Number of world species: 4.

Number of United States species: 1.

Key to the species (in China): Borchsenius, 1960.

Kuwanina quercus (Kuwana), 1902 Kuwana oak scale

Fig. 20, Color Plates 6, 7

Synonymy:

Sasakia quercus Kuwana.

Field Characteristics: Length of preadult sedentary females 1.75 mm. Length of mobile

adult females 2.25 mm. Very secretive, usually hiding under rough, loosened bark. The legless, bright red preadult females cover themselves with a hard greyish or white waxen cell which blends well with the color of the surrounding bark. The bright red adult females produce a dorsal mass of white waxen threads.

Biology: Unknown.

Similar Species: Species on oak which could be confused with *Kuwania quercus* in the field are Ehrhorn's oak scale (*Mycetococcus ehrhorni*), the oak eriococcin (*Eriococcus quercus*), and the oak margarodid (*Xylococcus quercus*).

Hosts: Normally restricted to oaks in the genus *Quercus*. California records are from *Quercus douglasii* and *Q. virginicus*. Recently collected from American chestnut (*Castanea dentata*).

Economic Importance: None.

Distribution: Originally described from Ja-

pan; known also from China and Formosa. In California, known from Yolo, Solano, Napa, San Mateo and San Joaquin Counties. It has been found infesting a commercial chestnut orchard at Linden, San Joaquin County. First found along Highway 128 in Yolo County, where it is very common.

Diagnosis: The illustration, made from California specimens, along with host restriction, is sufficient to distinguish this species as currently understood. However, the specific status of California specimens is suspect. Dr. John Beardsley (pers. comm.) has noticed differences between the California forms and those from Asia.

Ferris, G. F., 1950: Microentomol. 15(3):70.

Morrison, H., 1928: U.S. Dep. Agric. Tech. Bull. 52:1-239.

Kuwana, S. I., 1902: Proc. Calif. Acad. Sci. 3(3):47.

Genus *Margarodes* Guilding, 1829

Number of world species: 6 [according to Jakubski (1965)]. Note: While Jakubski places many species in other genera, some North American students of this group have not totally accepted his generic placements. Because of this, the one known California species will be left in *Margarodes* here for convenience.

Key to the world species: Jakubski (1965).

Key to the United States species: McDaniel, B., 1965: Proc. Entomol. Soc. Wash. 67(1):15-23. Plus more recent species descriptions by McDaniel, B., 1966: Proc. Entomol. Soc. Wash. 68(3):237-240, and LaRivers, I., 1967: Biol. Soc. Nev. Occ. Pap. 14:4-6.

Margarodes meridionalis Morrison, 1927 centipede grass ground pearl

Fig. 21, Color Plate 9

Synonymy:

Dimargarodes meridionalis (Morrison).

Field Characteristics: Length of sedentary preadult females up to 2.5 mm. Length of adult females 3.0 mm. The preadult forms enclose themselves in a tough, waxen, cyst-like covering. These cysts are ovoid or spheri-

cal in shape with a pearl-like luster; hence, the common name "ground pearls." Adult females have legs, the front pair designed for digging (see Color Plate 8). Adults appear to lack major wax secretions, except when a loose ovisac of white waxy filaments is formed.

Biology: All stages of the life cycle are proba-

bly spent on or below the soil surface. A complete life cycle probably takes from one to two years and possibly longer, depending on environmental conditions. One *Margarodes* species has survived up to 17 years in the cyst stage. For further information on biology, see Kouskolekas & Self (1973), Barnes et al. (1954), and Ebeling (1959).

Similar Species: No other known California scale insects should be confused with this species. At least nine closely related described species occur in the United States, but are thus far unknown from California except for one undescribed species (see Diagnosis). One species, *Margarodes chukar* LaRivers, occurs in the arid areas around Reno, Nevada, and intensive collecting may prove that it also occurs in adjacent areas of California. *Eumargarodes laingi* Jakubski is not only similar, but is also a serious pest of grasses in the South.

Hosts: This species is known from centipede grass, bermuda grass, zoysia grass, St. Augustine grass, lipia turf, and grapes.

Economic Importance: A serious pest of lawns, golf courses, and grass farms in the southern United States and Arizona. A pest of uncertain stature in the Imperial Valley of California on grass. Has infested grape vineyards in the same location. For further infor-

mation on economic importance and control, see Kouskolekas & Self (1973), Barnes et al. (1954), and Ebeling (1959).

Distribution: Known infestations in California are restricted so far to the Imperial Valley. Probably occurs under similar conditions in San Diego and Riverside Counties.

Diagnosis: The only described California ground pearl. Adult females can be separated from other related United States margarodids because they have enlarged fusiform setae on the abdomen and two central macroloculi in the central part of the multilocular pores. There is an apparently undescribed *Margarodes* known from Victorville, San Bernardino County. However, it lacks the fusiform setae.

Barnes, M. M., C. R. Ash, and A. S. Deal, 1954: Calif. Agric. 8(12):5,10.

Ebeling, W., 1959: Subtropical Fruit Pests. Univ. Calif. Div. Agric. Sci. Bull., Los Angeles. 436 pp.

Jakubski, A. W., 1965: A Critical Revision of the Families Margarodidae and Termitococcidae. Br. Mus. (Nat. Hist.), Gr. Britain. 187 pp.

Kouskolekas, C. A. and R. L. Self, 1973: Proc. Second Int. Turfgrass Res. Conf., Blacksburg, Va. pp. 421-423.

Genus *Matsucoccus* Cockerell, 1909

Number of world species: ?

Number of United States species: 17.

Keys to the world species: Boratynski (1952).

Keys to the United States species: Ray and Williams (1984).

Keys to the California species: Charles Ray (included here).

Most of the *Matsucoccus* from the western U.S. were described by Herbert (1919, 1921), McKenzie (1941, 1942, 1943) and Morrison (1939). The genus *Matsucoccus* in North America has been revised by Charles Ray of Auburn University.

Field Characteristics: Fully developed cyst stages are about 2 to 3 mm long. Adult females are 3 to 7 mm long. Cyst stages of most species are hidden under the bark of the host where they resemble pitch pockets and, depending on the thickness of the bark of the host species,

probably could be found only by peeling the bark back with an ax or similar cutting tool. Cyst stages of some species such as *Matsucoccus acalyptus* Herbert, *M. fasciculensis* Herbert, and *M. vexillorum* Morrison, will be found under the needle fascicles or otherwise at the bases of the needles. In heavy populations, those species found on pinyon pines may be found over the full length of the needle. These externally-occurring cysts are easily seen, brown, and resemble either seeds or fly pupae (see Color Plate 10,11). Adults of *Matsucoccus* are red, green or brown and are free of wax secretions except for loose, woolly material (see Color Plates 11, 16) and a similar loose ovisac. They will occasionally be found wandering about on the tree searching for a place to settle and lay eggs. Females of one species, *M. acalyptus*, often congregate in large numbers at the base of the host tree where the eggs are laid. The above information was summarized from McKenzie (1942b, 1943), Keen (1952), McCambridge (1974), and Furniss & Carolin (1977). For information on biological control of *Matsucoccus* see McClure (1987).

Similar Species: Scales in the genus *Pityococcus* are most similar in the field. No other similar margarodids are found on California pines, except *Desmococcus captivus* McKenzie. Adults of needle-infesting species like *Matsucoccus acalyptus* may resemble some of the conifer aphids, and the needle-inhabiting cysts look like aphid eggs.

Hosts: Pines only.

Economic Importance: Several species in the *Matsucoccus* group are serious pests of pines in the United States. High populations occur frequently and often serious outbreaks occur for several years in a row. Injury includes needle drop, shortened needles, weakened crowns, chlorosis in mature trees, and deformation or death in young trees. Ponderosa and Jeffrey pines which are infested often show a characteristic "flagging" caused by retention of dead needles on dead branchlets. Injury often resembles that due to other causes such as white pine blister rust or certain other types of stress, and since the scales are often difficult to detect, symptoms may be misdiagnosed. Trees infested with *Matsucoccus* become very susceptible to attack by *Ips confusus* (LeConte) and other bark beetles. The major pests in this group are the red pine scale (*M. resinosae* Bean & Godwin) in the New England states; *M. vexillorum* Morrison in New Mexico and Arizona; *M. acalyptus* Herbert in California, Arizona, and the Southwest; and *M. bisetosus* Morrison in California and the West. The above economic information was summarized from McKenzie (1942b, 1943), Keen (1952), McCambridge (1974), and Furniss & Carolin (1977). For information on natural enemies see Mendel et al (1991).

Distribution: Northern Hemisphere. Of the North American species of *Matsucoccus*, most occur in California or the Southwest. The California distribution is based on too few collections. The estimated range for these species is probably much greater than indicated, but since these scales are so difficult to collect, it is impossible to be sure of their exact distributional pattern. A number of species are known from Eurasia. *Matsucoccus resinosae* (Bean & Godwin), an economic species known from the northeastern United States, may have been introduced from Japan and probably is a synonym of *M. matsumurae* (Kuwana). See McClure (1983).

Diagnosis: Keys to the species of *Matsucoccus* have been developed for the United States by Ray (1982) and by Ray & Williams (1984). The key to California species is provided here by Charles Ray. *Matsucoccus* and *Pityococcus* may be easily separated because the tarsi are two-segmented in *Matsucoccus* and one-segmented in *Pityococcus*. For more information on the subfamily containing *Matsucoccus*, see Beardsley (1968).

Beardsley, J. W., 1968: Ann. Entomol. Soc. Am.. 61:1449-1459.

Boratynski, K. L., 1952: Trans. R. Entomol. Soc London 103:285-326.

Furniss, R. L. and V. M. Carolin, 1977: U.S. Dep. Agric. Misc. Publ. 1339:1-654.
Herbert, F. B., 1921: Proc. Entomol. Soc. Wash. 23:15-22.
Keen, F. P., 1952: U.S. Dep. Agric. Misc. Publ. 273:1-280.
McCambridge, W. F., 1974: U.S. For. Serv. For. Pest Leaflet. 148:1-4.
McClure, M. S., 1983: Ann. Entomol. Soc. Am. 76:761-765.
McClure, M. S., 1987: Envir. Entomol. 16(1):224-230.
McKenzie, H. L., 1942b: Microentomol. 7(1):19-24.
McKenzie, H. L., 1943: Microentomol. 8:42-52.
Mendel, Z., E. Carmi and H. Podoler, 1991: Ann. Entomol. Soc. Am. 84(5):502-507.
Morrison, H., 1939: Proc. Entomol. Soc. Wash. 41(1):1-20.
Ray, C. H. Jr., 1982: Unpubl. Ph.D thesis. Auburn University, Auburn Alabama. 282 pp.
Ray, C. H. Jr. and M.L. Williams, 1984: Ann. Entomol. Soc. Am. 77:765-769.

KEY TO CALIFORNIA SPECIES OF MATSUCCUS

by Charles H. Ray, Jr.

- 1. Adult females with an apical cluster of multilocular disc pores, each with a bilocular duct opening in its center 4
- Adult females without an apical cluster of multilocular disc pores 2

- 2. Adult females with fleshy setae only on terminal 4 antennal segments; occurring primarily on pinyon pine (*Pinus edulis*, *P. monophylla*) *Matsucoccus acalyptus*
- Adult females with fleshy setae on terminal 5 antennal segments; occurring only on pines of subgenus *Pinus*, section *Pinus* 3

- 3. First instars with terminal 4 abdominal spiracular atria at apices of distinct tubercles *Matsucoccus secretus*
- First instars with terminal 4 abdominal spiracular atria not at apices of distinct tubercles *Matsucoccus fasciculensis*

- 4. Adult females with all body setae approximately equal in length; known to occur only on *Pinus ponderosa* and *P. jeffreyi* *Matsucoccus californicus*
- Adult females with body setae of 2 distinct sizes, setae near coxae and midventral setae 2 or more times length of other body setae 5

- 5. Adult females with smallest cicatrices greater than 10 μ in diameter; occurring only on *Pinus monophylla* *Matsucoccus monophyllae*
- Adult females with largest cicatrices less than 10 μ in diameter; not known to occur on *Pinus monophylla* 6

- 6. Adult females with 2 large setae on each trochanter; cicatrices numerous, usually more than 110 in number; adult males pterygote; known only from pines of subgenus *Pinus*, section *Pinus* *Matsucoccus bisetosus*
- Adult females usually with only 1 large seta on each trochanter, cicatrices few, usually less than 30 in number; adult males apterous; known only from pines of subgenus *Strobilus*, section *Strobilus* *Matsucoccus paucicicatrices*

***Matsucoccus acalyptus* Herbert, 1921**
pinyon needle scale

Fig. 22, Color Plate 10, 11

Field Characteristics: Fully grown immature cyst stage 1.5 mm long and 0.7 mm wide; black; bean-shaped (McCambridge, 1974), resemble aphid eggs. Adult females to 3.0 mm long; brown or reddish brown; resembling a mealybug without the mealy wax; widest posteriorly. Eggs yellow, laid in masses surrounded by loose, cottony white wax (Furniss & Carolin, 1977). Males winged.

Biology: One generation per year. Mating occurs in April; eggs hatch by May; last stage nymphs are formed in late August. Overwintering occurs in the last nymphal stage. Nymphal stages feed on the needles. Adult females migrate to the trunk and larger branches of the host tree where eggs are laid. Male pupae are formed in cocoons under sticks and pebbles near the base of the tree. The above biological information summarized from McCambridge & Pierce (1964) and Furniss & Carolin (1977).

Hosts: Pinyon pines, foxtail pines.

Economic Importance: Causes weakened trees, due to needle drop. Young trees may be

killed outright. Trees weakened by this scale become more susceptible to attack by bark beetles. Not generally of economic concern in California. Serious outbreaks have occurred in Colorado and Arizona. The above economic information summarized from McCambridge (1974).

Distribution: In California, probably occurs wherever one-needle pinyon occurs. Also known from Arizona, New Mexico, Utah, Colorado, and Idaho.

Furniss, R. L. and V. M. Carolin, 1977: U.S. Dep. Agric. Misc. Publ. 1339: 1-654.

Herbert, F. B., 1921: Proc. Entomol. Soc. Wash. 23:15-22.

McCambridge, W. F. and D. A. Pierce, 1964: Ann. Entomol. Soc. Am. 57:197-200.

McCambridge, W. F., 1974: U.S. For. Serv. For. Pest Leaflet. 148:1-4.

Pierce, D. A., W. F. McCambridge, and G. E. Moore, 1968: J. Econ. Entomol. 61:1697-1698.

***Matsucoccus bisetosus* Morrison, 1939**
ponderosa pine twig scale

Fig. 23

Other common names:

two-setae matsucoccus.

Field Characteristics: Fully grown, immature cyst stage 2 mm in diameter; brown; sclerotized; generally circular in dorsal view, but overall shape varies with the size and shape of the bark crevices where they are found. Adult females 4 mm long, brown, broadest posteriorly. The above information summarized from McKenzie (1942b).

Biology: One yearly generation. According to McKenzie (1942b), eggs are laid under bark scales and in bark crevices in April. However, collections from Nevada County in 1986 indicate that many females oviposit between the bracts of the spent male flowers. Crawlers hatch, wander about, and also settle under loose bark and in bark cracks. Second stage cysts are formed in July and August. Overwintering takes place in the second stage.

SCALE INSECTS OF CALIFORNIA

Adult males and females emerge in March and April, depending on temperature and elevation. Part of the above biological information summarized from McKenzie (1941a, 1942b) and Furniss & Carolin (1977).

Similar Species: Scales in this genus and in the genus *Pityococcus*.

Hosts: Jeffrey, Ponderosa, Monterey, Coulter, foothill, and lodgepole pines.

Economic Importance: Considered the most damaging of the *Matsucoccus* scales in California. Feeds on the trunks, branches, and twig axils, causing shortened, unhealthy needle

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growth, weakened and dead twigs, and trees which are more susceptible to bark beetle attack (Furniss & Carolin, 1977).

Distribution: Generally distributed in the State wherever the hosts occur naturally.

Furniss, R. L. and V. M. Carolin, 1977: U.S. Dep. Agric. Misc. Publ. 1339:1-654.

McKenzie, H. L., 1941a: J. Econ. Entomol. 34:783-785.

McKenzie, H. L., 1942b: Microentomol. 7(1):19-24.

Matsucoccus californicus Morrison, 1939 California matsucoccus

Fig. 24

Field Characteristics: Similar in appearance and habits to *M. bisetosus*.

Biology: Apparently one yearly generation. Found in cells and crevices deep beneath the outer bark layer of the host trunk.

Hosts: Ponderosa and Jeffrey pines.

Distribution: Burgess Spring, Lassen County, California; possibly Arizona.

Morrison, H., 1939: Proc. Entomol. Soc. Wash. 41(1):1-20.

Matsucoccus fasciculensis Herbert, 1919 needle fascicle scale

Fig. 25, Color Plate 12

Other Common Names:

fasciculate pine scale, three-leaf pine scale.

Field Characteristics: Similar to *M. bisetosus*.

Biology: Apparently one yearly generation. Second instar cyst stage usually found between the needles near the outer end of the needle sheath or fascicle.

Hosts: Ponderosa, Jeffrey, and foothill pines.

Economic Importance: Amount of damage not recorded in the literature. Causes discol-

oration and necrosis of needles at the feeding sites.

Distribution: Probably generally distributed in the state wherever the hosts occur naturally. Recorded from El Dorado, San Benito, Shasta, and Sonoma Counties, California; Oregon and Idaho.

Herbert, F. B., 1919: Proc. Entomol. Soc. Wash. 21(7):157-161.

Matsucoccus monophyllae McKenzie, 1941
one-needle pinyon scale

Fig. 26, Color Plate 13-16

Other Common Names:

one-leaf pine scale.

Field Characteristics: Similar to *M. bisetosus*, but smaller. Females light brown with a yellowish tranverse abdominal band.

Biology: One yearly generation. Second instar cyst stage occurs on bark at bases of needle bundles, in twig and branch axils, and in bark cracks. The above information summarized from McKenzie (1941) and Furniss & Carolin (1977). Cysts collected from Westgard Pass, Inyo County on April 2 hatched between April 10 and April 17 (males first). Females exhibited a pheromone calling

procedure with the abdomen raised and the antennae vibrating rapidly.

Hosts: One-needle pinyon (*Pinus monophylla*). Furniss & Carolin (1977) list it on *Pinus edulis*.

Economic Importance: Heavily infested trees exhibit branch die-back and "flagging" (McKenzie, 1941).

Distribution: Los Padres National Forest, Kern County; Bishop, Inyo County.

McKenzie, H. L., 1941b: Microentomol. 6(1):2-5.
Furniss, R. L. and V. M. Carolin, 1977: U.S. Dep. Agric. Misc. Publ. 1339:1-654.

Matsucoccus paucicatrices Morrison, 1939
sugar pine matsucoccus

Fig. 27

Field Characteristics: Similar to *M. bisetosus*.

Biology: Probably one yearly generation. Second instar cyst stage occurs on bark at bases of needle bundles, in twig and branch axils, and in bark cracks.

Hosts: Sugar pine, western white pine, and limber pine.

Economic Importance: Causes death of needles, twig dieback, resining and cracking of the bark, and weakening and deformation or death of small trees. Causes unthriftiness and bark beetle susceptibility in older trees. Symptoms caused by this scale resemble

symptoms caused by white pine blister rust. The above information summarized from McKenzie (1941c) and Furniss & Carolin (1977).

Distribution: Butte, Kern and Mariposa Counties, California; various localities in Oregon, Montana, and Wyoming.

Furniss, R. L. and V. M. Carolin, 1977: U.S. Dep. Agric. Misc. Publ. 1339:1-654.

McKenzie, H. L., 1941c: J. For. 39(5):488-489.
Morrison, H., 1939: Proc. Entomol. Soc. Wash. 41(1):1-20.

Matsucoccus secretus Morrison, 1939
secretive pine scale

Fig. 28

Field Characteristics: Similar to *M. fasciculensis* and *M. bisetosus*.

Biology: Unknown, but probably has one

yearly generation. According to Morrison (1939), occurs secreted deeply within the bundle sheath at the bases of the needles.

Hosts: Ponderosa pine.

Distribution: Willow Spring, Lassen County, California; Arizona, Nevada, Colorado, New Mexico, Mexico.

Morrison, H., 1939: Proc. Entomol. Soc. Wash. 41(1):1-20.

Genus *Pityococcus* McKenzie, 1942

Number of world species: 3.

Number of United States species: 3.

Key to the species: McKenzie, H. L., 1942a: Microentomol. 7(1):19-24.

Pityococcus deleoni McKenzie, 1942

DeLeon pinyon scale

Fig. 29, Color Plates 17, 18

Field Characteristics: Adult females 1.0 to 1.5 mm long; pinkish-yellow; broadest posteriorly; active, resembling thrips nymphs. Cyst stages unknown.

Biology: Unknown, but probably with a one-year life cycle. Females are active in February and March. They are found laying eggs under green lichens at that time. The nymphal cyst stages have not been collected, and their feeding sites have not been located.

Similar Species: Scales in the genus *Matsucoccus*.

Hosts: Four-needle pinyon pine.

Distribution: Laguna Mountains, San Diego

County, California. Known only from the type locality, a small grove of four-needle pinyon pines on a north-facing canyon wall one mile east of Mt. Laguna, San Diego County.

Diagnosis: Separated from *P. ferrisi* by the small, nearly indiscernible abdominal spiracles in this species compared to the large, readily visible spiracles. Separated from *Matsucoccus* by the one-segmented tarsi.

McKenzie, H. L., 1942: Microentomol. 7(1):1-18.

Pityococcus ferrisi McKenzie, 1942

Ferris' pine scale

Fig. 30

Field Characteristics: Adult females 1.5 to 2.5 mm long; width 0.8 to 1.3 mm; elongate, parallel sided. Second stage cyst 0.50 to 0.75 mm in diameter; ovoid to circular depending on the shape of the feeding site. Field appearance otherwise unknown.

Biology: Unknown. Probably has one yearly generation. Feeding sites are under bark scales and in bark crevices on the trunks, branches, and twig axils of the host.

Similar Species: Scales in the genus *Matsucoccus*.

Hosts: Sugar pine, white pine, and pinyon pine (*P. edulis*). zona, New Mexico, Colorado.

Distribution: Lassen, Tulare, Mariposa, Inyo, and Trinity Counties, California; Utah, Arizona, New Mexico, Colorado. McKenzie, H. L., 1942a: Microentomol. 7(1):1-24.

Genus *Steatococcus* Ferris, 1921

Color Plates 19, 20

Number of world species: 8.

Number of United States species: 2.

Number of California species: 1. (**Note:** There is probably at least one undescribed species of *Steatococcus* from creosote bush (*Larrea*) in southeastern California. This species is often found on the crowns and larger roots of the host, particularly during the nymphal stages).

Key to the world species: Morrison, H., 1928: U.S. Dep. Agric. Tech. Bull. 52:1-239.

Steatococcus townsendi (Cockerell), 1896

Townsend margarodid

Fig. 31

Synonymy:

Icerya townsendi Cockerell, *Palaeococcus townsendi* (Cockerell).

Field Characteristics: Adult females 5 mm long; subglobose or round; dark-pink to purple; covered with a thin white or yellow mealy secretion which is arranged in dorsal and sublateral series of wart-like prominences.

Biology: Found on aerial plant parts, but the type specimens were collected from the bases of branches. Otherwise unknown except that it is ovoviviparous, the eggs being held in a ventral invaginated abdominal pouch called a marsupium. Adult females apparently active in late summer.

Similar Species: A very similar, possibly undescribed species of *Steatococcus* is commonly encountered on creosote bush (*Larrea*), in southeastern California; it cannot be separated from *townsendi* in the field except for host preference. Mealybugs resemble this species, but they are usually smaller and lack the longitudinal dorsal wax tufts and the pink to purple color.

Hosts: The New Mexico collections are from composites in the genera *Pluchea* and *Gutierrezia*. The California records are from *Ambro-*

sia eriocentra and *Peucephyllum schottii*.

Distribution: California records are from Hackberry Mountain, San Bernardino County, and Shaver's Well, Riverside County. **Diagnosis:** Host plant preferences and the morphology illustration provided should aid in recognition. However, members of the genus are very rare in collections and the taxonomy of the group is poorly understood. There may be several undescribed species in the southwest as well. A common species, *Steatococcus morrilli* (Cockerell), found on *Prosopis* in Arizona is very similar to this species morphologically except that in *morrilli* the smaller setae are much thicker, very straight, and spinelike. The smaller setae in *townsendi* are hair-like. *Palaeococcus pluchae* (Cockerell) may be a synonym of this species according to Morrison (1928). **Note:** the cicatrices (one large and two lateral smaller circulus-like structures on the abdominal venter of some Margarodids) and the vulvar area are both drawn up into the marsupial invagination in specimens of *Steatococcus*.

Morrison, H., 1928: U.S. Dep. Agric. Tech. Bull. 52:1-239.

Genus *Stomacoccus* Ferris, 1917

Number of world species: 2.

Number of United States species: 2.

Key to the species: Ferris, G. F., 1941: Microentomol. 6(1):29-32.

***Stomacoccus platani* Ferris, 1917
sycamore scale**

Fig. 32, Color Plates 21-23

Field Characteristics: Sedentary nymphal stage up to 1.5 mm long; adult female 2.0 mm long. An infestation is recognized by the yellow or brown necrotic spots which first appear on the young leaves in early spring (see Color Plate 23). If the undersides of these spotted leaves are examined, the egg-like yellowish preadult females or their empty cast skins will be seen (Color Plate 22, 23). Adult forms are yellowish and greatly resemble thrips nymphs.

Biology: Adults migrate from the bark to the leaves in spring. As many as 9 yearly generations have been recorded, including the leaf and bark generations. Summer development occurs on the leaves through three to five generations. At certain times of the year, the scales also develop on the bark where they produce large amounts of cottony wax. The above biological information summarized from Brown & Eads (1965) and Hamilton (1977). For a thorough study on the life history and ecology of this species, see Calderwood (1945).

Similar Species: Adults resemble thrips nymphs; immature stages resemble insect eggs. However, injury symptoms caused by this scale on the host should identify it.

Hosts: Native and introduced sycamores in the genus *Platanus*.

Economic Importance: A serious pest of ornamental sycamores; control is sometimes necessary. For information on economic im-

portance and control, see Brown & Eads (1965) and Hamilton (1977). Injury consists of unsightly spotted and deformed leaves and premature leaf drop.

Distribution: Throughout California.

Diagnosis: The illustrations indicate the important distinguishing characteristics of this species. *S. platani* is the only cyst-forming California margarodid which always has mouth parts in the adult female. The morphology, host plant restrictions, and field characters identify this species in California. *Stomacoccus capsulatus* Ferris on *Platanus* from southern Arizona is similar but differs particularly in having 20 or more tarsal claw digitules instead of the 6 to 12 digitules found in *S. platani*.

Brown, L. R. and C.O. Eads, 1965b: Calif. Agric. Exp. Stn. Bull. 818:1-38.

Calderwood, M. M., 1945: Unpubl. Master's Thesis, Stanford University.

Ferris, G. F., 1941: Microentomol. 6(1):29-32.

Hamilton, D., 1977: Univ. Calif. Div. Agric. Sci. Leaflet No. 2545:1-2.

Smith, R. H., 1941: Proc. West. Shade-tree Conf. 8:30-39.

Smith, R. H., 1944: Arborist's News 9:9-15.

Smith, R. H., 1945: Pac. Coast Nurseryman 3:7, 8, 13.

Genus *Xylococcus* Morrison, 1927

Number of world species: 4.

Number of United States species: 4.

Key to the species: Florence, L., 1917: Ann. Entomol. Soc. Am. 10:147-166.

***Xylococcus betulae* (Pergande), 1898**
 birch margarodid

Fig. 33, Color Plates 24-26

Other Common Names:

alder scale.

Synonymy: *Xylococcus betulae* Pergande, *Xylococcus alni* Florence, *Xylococcus alni* (Florence). Note: *Xylococcus alni* Oguma is a distinct species known only from Japan.

Field Characteristics: Essentially identical to *X. quercus* in all respects except hosts. See Field Characteristics under *X. quercus*.

Biology: Apparently similar to that of *X. quercus*. For information on the biology of *betulae* in the eastern states, see Hubbard & Pergande (1898).

Similar Species: Identical to *X. quercus* in the field.

Hosts: Birch, beech, willow, and alder. Essig (1934) also lists it from prune in the Santa Clara Valley.

Economic Importance: Can injure and reduce the quality of beech trees grown for lumber in the northeastern United States. For more information, see Shigo (1962) and Hepting (1971). Very rare and non-economic in California.

Distribution: The species as it is now understood occurs in Santa Clara and Del Norte Counties in California, in Washington, and in the north-eastern United States. The actual distribution of this species in California is not

known because of the current taxonomic status of the group.

Diagnosis: The taxonomic status of this species is confused. *Xylococcus alni* (Florence) was considered a synonym of this species by Ferris (1919) and *X. quercus* may also be a synonym of it according to Ferris (1920). The separating morphological characteristics listed by Florence (1917) are not reliable, and these species cannot be separated morphologically. An illustration of *X. quercus* is provided here which will be adequate for recognition of this species until the status of the complex can be straightened out.

Essig, E.O., 1934: Pan-Pacif. Entomol. 10(1):44.

Ferris, G. F., 1919a: Can. Entomol. 51:108-113.

Ferris, G. F., 1920: Stanford Univ. Publ., Univ. Ser., Biol. Sci. 1:1-57.

Florence, L., 1917: Ann. Entomol. Soc. Am. 10:147-166.

Hepting, G. H., 1971: U.S. Dep. Agric. For. Serv. Agric. Handb. 386:1-658.

Hubbard, H. G. and T. Pergande, 1898: U.S. Dep. Agric. Div. Entomol. Bull. (n.s.) 18:13-26.

Shigo, A. L., 1962: U.S. For. Serv. Northeast For. Exp. Stn. Pap. 168:1-13.

***Xylococcus macrocarpae* (Coleman), 1908**
 incense cedar scale

Figs. 34-39, Color Plates 27-30

Other Common Names:

cypress xylococcus.

Synonymy:

Xylococcus macrocarpae Coleman.

Field Characteristics: Length of preadult stage to 4.0 mm; adult females up to 7.0 mm. Preadult females dark red with chitonized posterior areas brown. Adults brownish with lighter appendages. The presence of this scale is noticeable on the host, but it is difficult to find. The bark of the trunk and larger branches exhibits a blackish appearance caused by sooty mold, along with mealy white wax produced by previous generations of scales. Preadult females will be found only by peeling back layers of loose bark. Adult females occasionally will be found wandering about on the bark or forming an immobile egg laying stage (Color Plate 30) on the needles.

Biology: Adult females most commonly collected in April and May. Has one generation per year. The biology has been thoroughly studied by Tate (1986) and Tate et al. (1990).

Similar Species: The cypress bark mealybug (*Ehrhornia cypressi*) resembles the preadult females, but is normally found on cypress in urban areas. Other species of *Xylococcus* and species of *Matsucoccus* are similar in shape, but have different hosts.

Hosts: Incense cedar, Monterey cypress, *Juniperus scopularum*, *Cupressus sargentii*.

Economic Importance: Causes host trees to be debilitated and unsightly in appearance. Young trees growing in shaded locations seem to be most affected. For more information see Salman (1933). For information on natural enemies see Beardsley & Gordh (1988)

and Tate et al. (1990).

Distribution: Throughout California wherever native incense cedar and Monterey cypress are found. Seems to be restricted to stands of native trees and normally is not found in urban areas. Also occurs in Utah and probably other western states.

Diagnosis: Descriptions, photographs, and keys of three of the four known North American species are given by Florence (1917). Keys to the three species are based on various stage nymphs. Although much larger in size, adult females of *X. macrocarpae* resemble some of the larger species of *Matsucoccus* and *Pityococcus* morphologically. *Xylococcus* has atrial spiracular pores and thoracic spiracles somewhat larger than the abdominal spiracles. Immature males of *Xylococcus* have legs and resemble adult female *Matsucoccus*, but they are distinguishable because the males have spiracular atrial pores and no vulva. It should be noted that the presence or absence of dorsal abdominal multilocular pores is a variable characteristic of this species.

Beardsley, J.W., Jr. and G. Gordh, 1988: Proc. Hawaiian Entomol. Soc. 28:161-168.

Florence, L., 1917: Ann. Entomol. Soc. Am. 10:147-166.

Salman, K. A., 1933: Calif. Dep. Agric. Mon. Bull. 22(2-3):132.

Tate, S.M., 1986: Unpublished Master's thesis. Univ. Calif. Berkeley. 71 pp.

Tate, S.M. et al, 1990: Hilgardia 58(2):1-19.

***Xylococcus quercus* (Ehrhorn), 1900**
oak xylococcus scale

Fig. 40, Color Plates 31-33

Synonymy:

Xylococcus quercus Ehrhorn.

Field Characteristics: Adult females 4 to 10 mm long; elongate-oval; dull reddish brown; covered with a thin layer of white mealy wax, resembling large, dark-colored mealybugs. Adult females imbedded in cells in cracks in the bark, although the females leave the nymphal cells and wander about prior to oviposition. Immature stages, except for the crawlers, are legless. Immatures live in waxen cells formed in cracks between layers of bark. Nymphs crimson; surrounded by white cottony wax secretions. The nymphs produce a single long waxen tube up to 1/2 inch long which extends outward at right angles to the surface of the bark (Color Plate 25). The purpose of the waxen tube is probably for the removal of honeydew away from the opening to the nymphal cell and from the surrounding bark surface.

Biology: Infests trunk and older branches; presence may be indicated by long, thin, white wax filaments which issue from the cracks in the bark. Apparently one generation per year. Males active in autumn; females overwinter and produce eggs during winter and spring. For more information, see Florence (1917).

Similar Species: Other species of *Xylococcus* are similar, particularly *X. betulae*. *X. macrocarpae* is similar but prefers conifers, while this species prefers hardwoods. Resembles the mealybug groups in appearance, but much larger.

Hosts: Prefers canyon oak (*Quercus chrysolepis*), but is known from at least one other oak species and possibly also from chestnut (*Cas-*

tanea). See comments under Diagnosis.

Economic Importance: None.

Distribution: Known primarily from the San Francisco Bay area; collected by Ehrhorn and Florence in Permanente Creek and Stevens Creek Canyons in Santa Clara County and in other scattered locations in the coast range nearby. A heavy infestation was discovered on the trunks of several large valley oaks at Lodi, San Joaquin County in 1981. Other collections, not definitely determined to species, indicate that the species may be widely distributed in central and northern California. Rare and localized in areas where it occurs.

Diagnosis: Host preferences and the morphological illustrations provided will aid in recognition. Ferris (1919a) questions the validity of the species. It is Ferris' opinion, as well as this author's opinion, that *X. quercus* is probably a synonym of *X. betulae*. These two species, based on less than ample numbers of specimens, cannot be separated morphologically although further studies of other life stages, particularly crawlers and adult males, may prove valuable in solving these problems. Florence's (1917) key to the species does not appear to be an adequate means of separating the species. This information, plus the records of this species on oak and the records of *X. betulae* on birch, beech, alder, and prune, indicate that only one polyphagous species may exist.

Ferris, G. F., 1919a: Can. Entomol. 51:108-113.
Florence, L., 1917: Ann. Entomol. Soc. Am. 10:147-166.

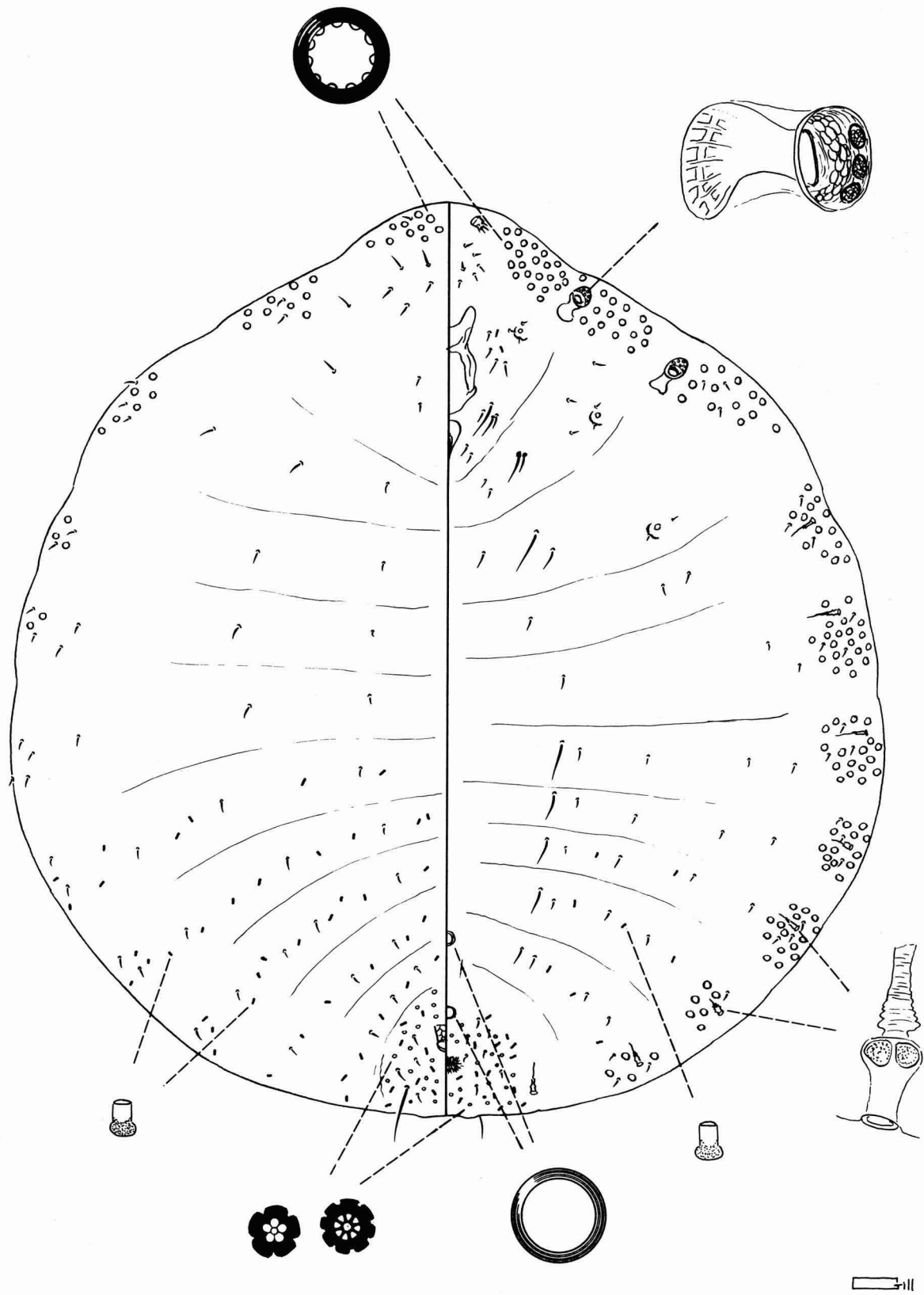


Fig. 18: *Desmococcus captivus* McKenzie.

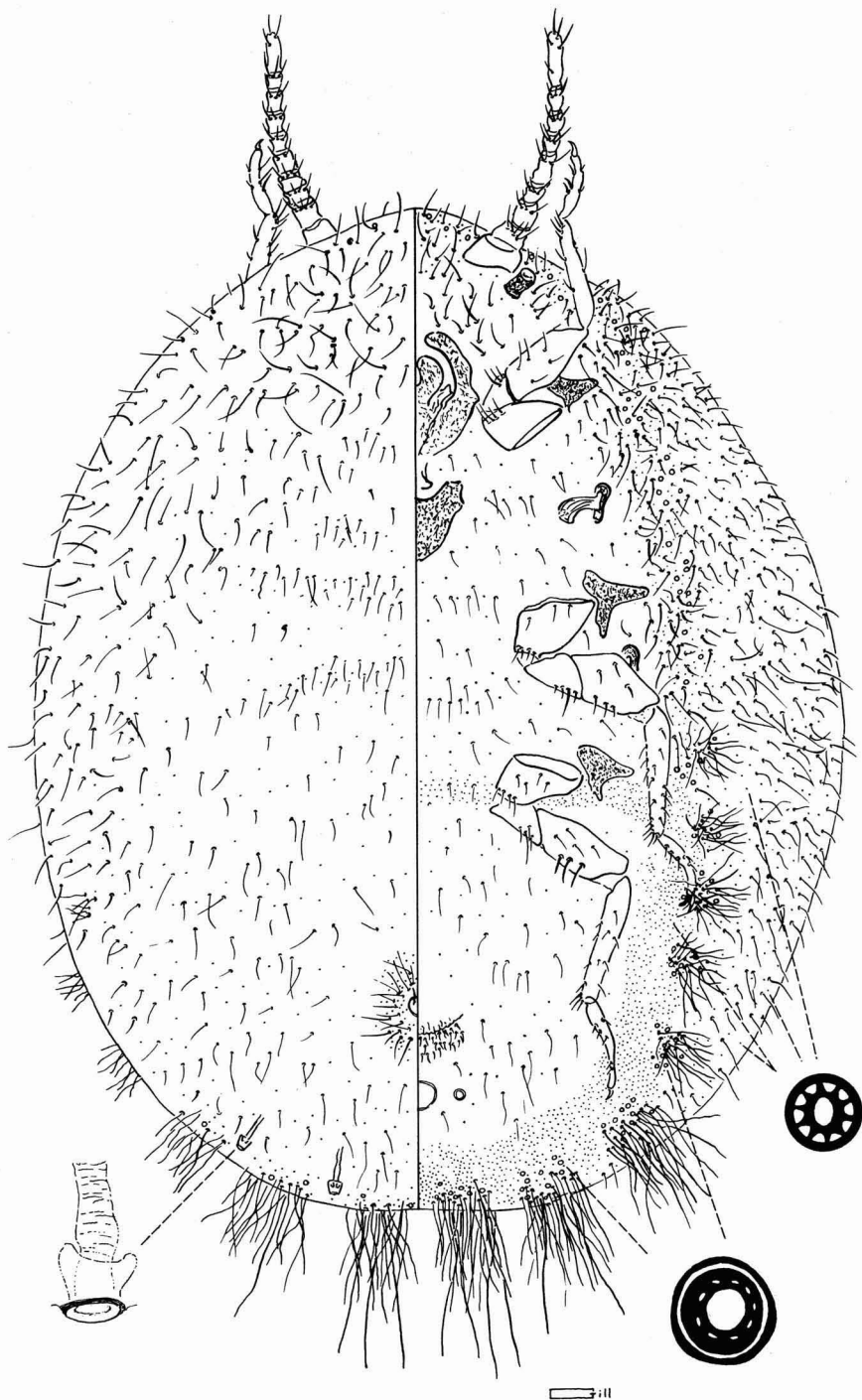


Fig. 19: *Icerya purchasi* Maskell.

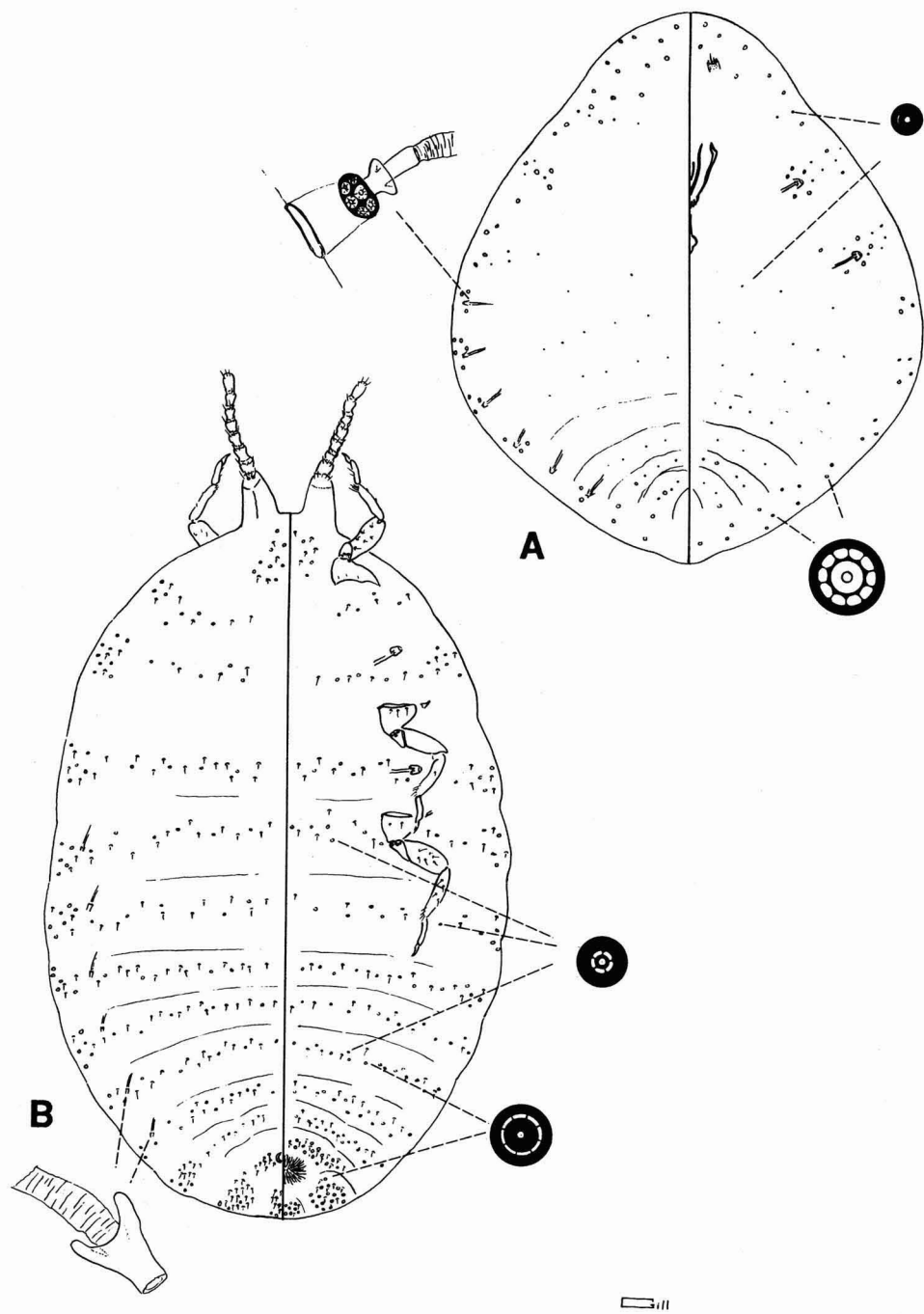


Fig. 20: *Kuwania quercus* (Kuwana). A. nymph. B. adult female.

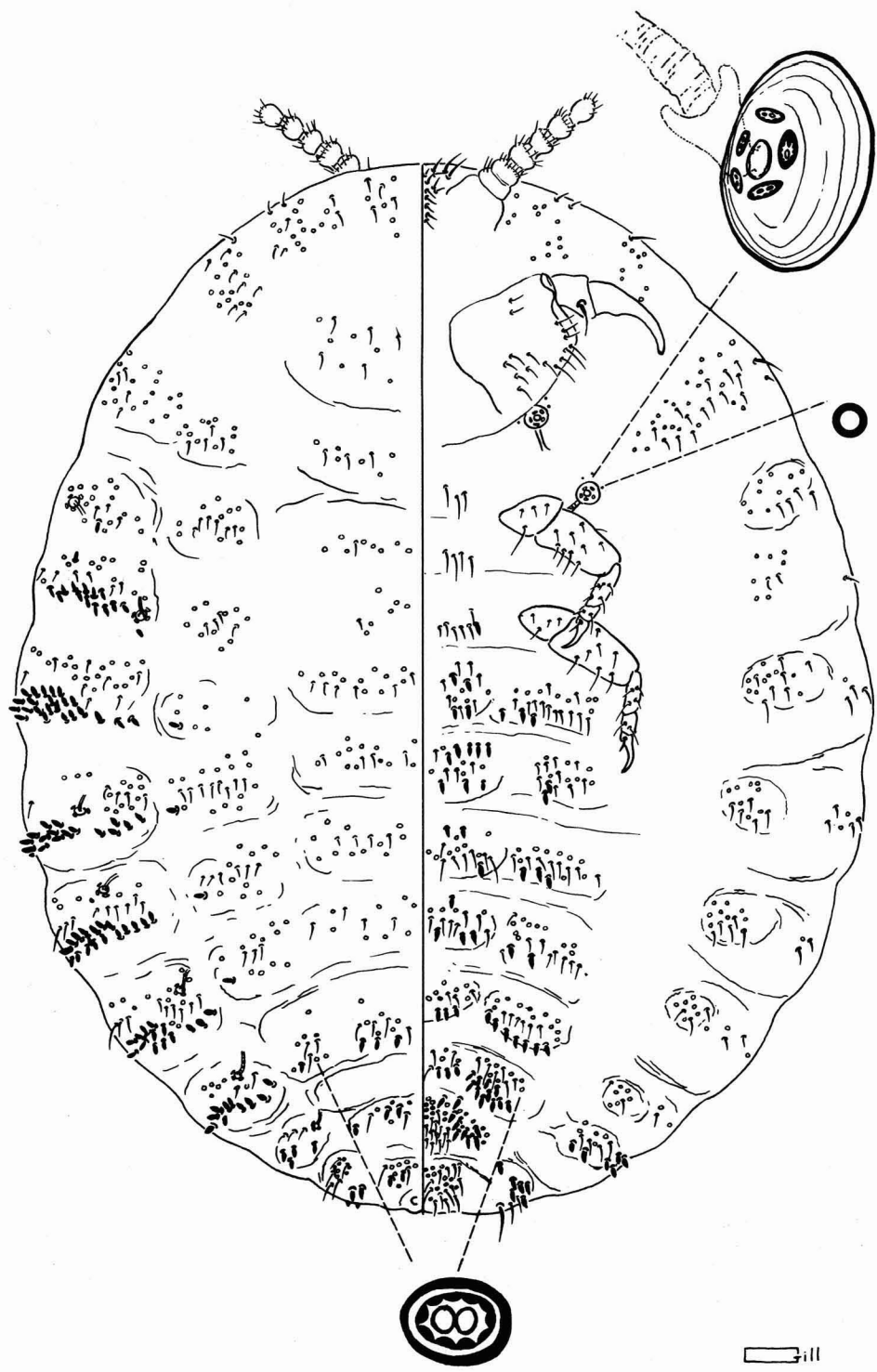


Fig. 21: *Margarodes meridionalis* Morrison.

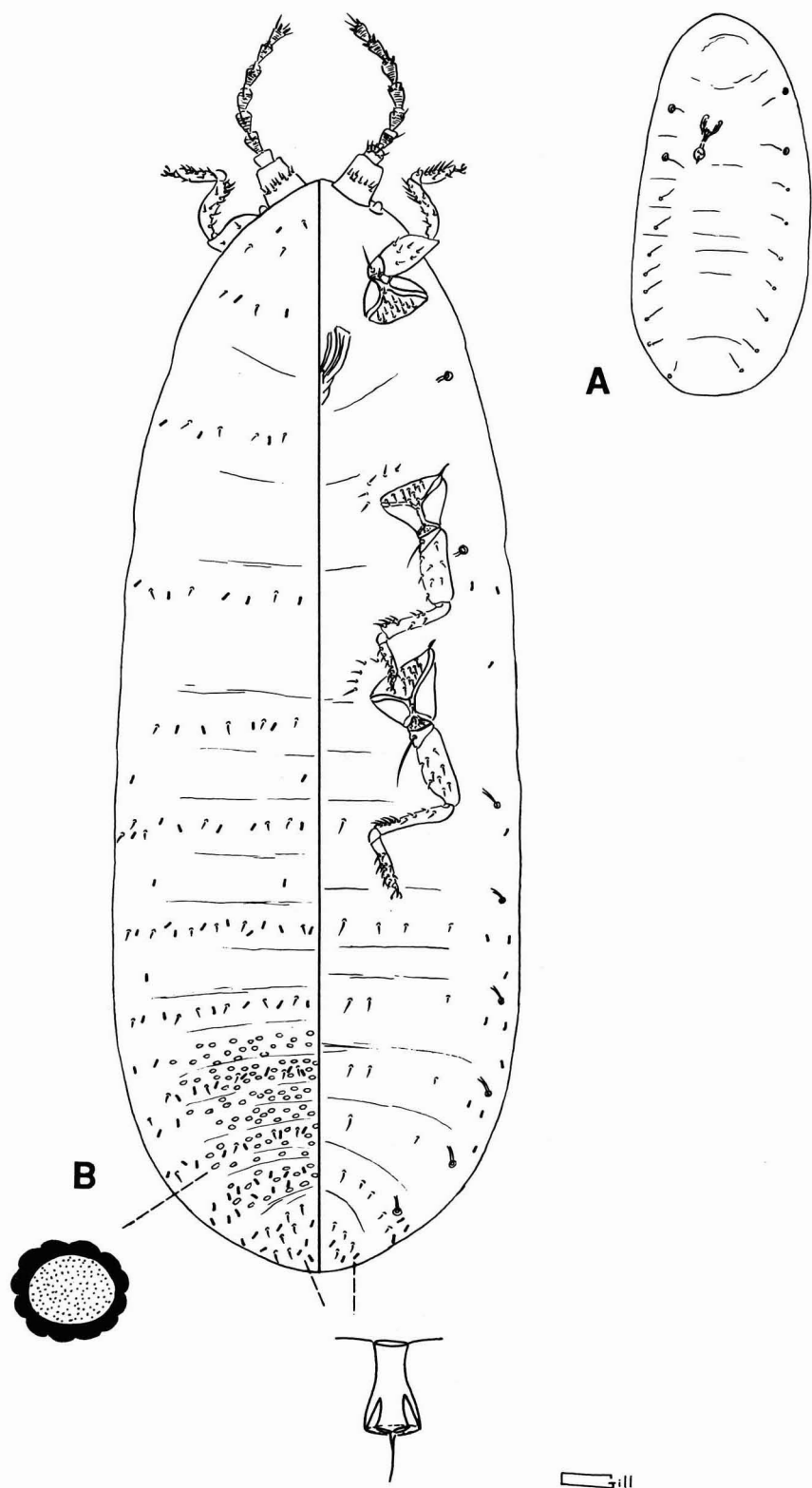


Fig. 22: *Matsucoccus acalyptus* Herbert. A. nymph. B. adult female.

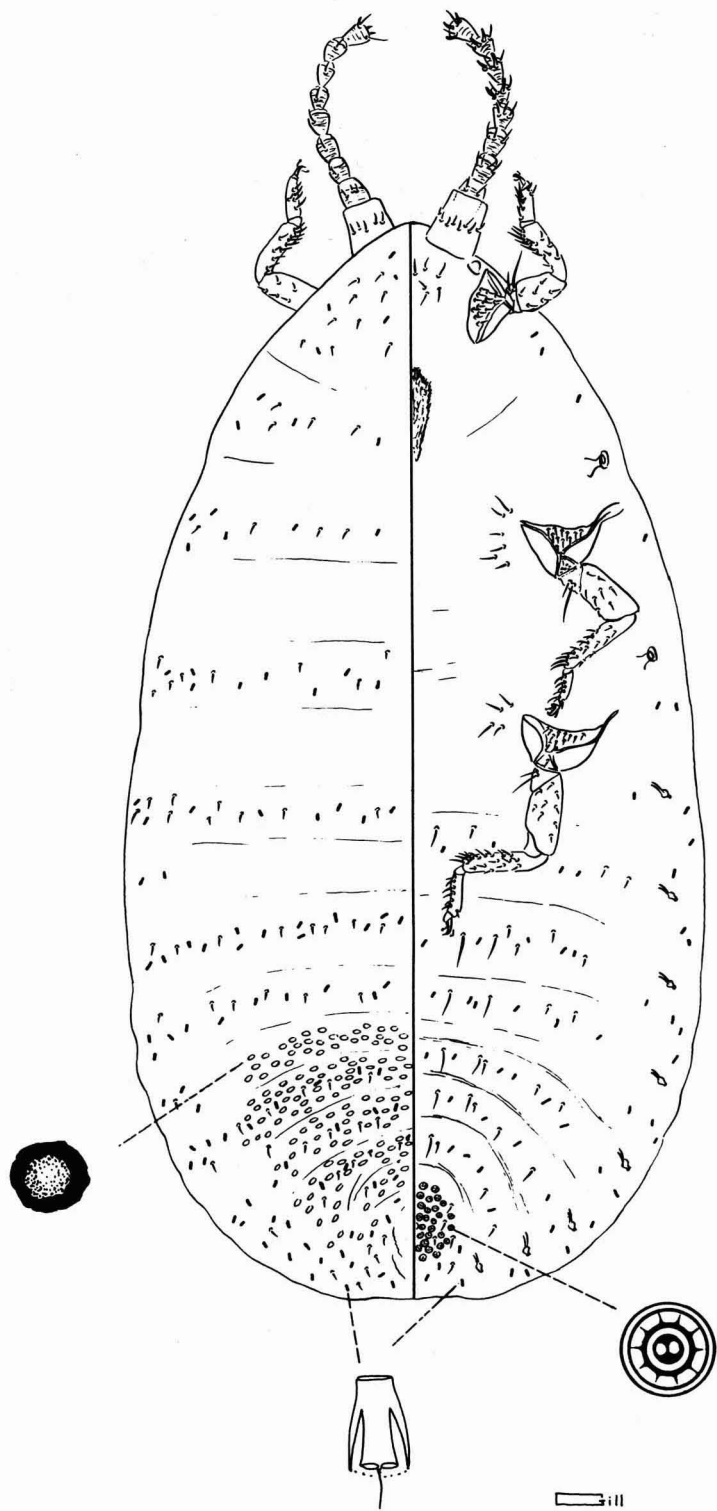


Fig. 23: *Matsucoccus bisetosus* Morrison.

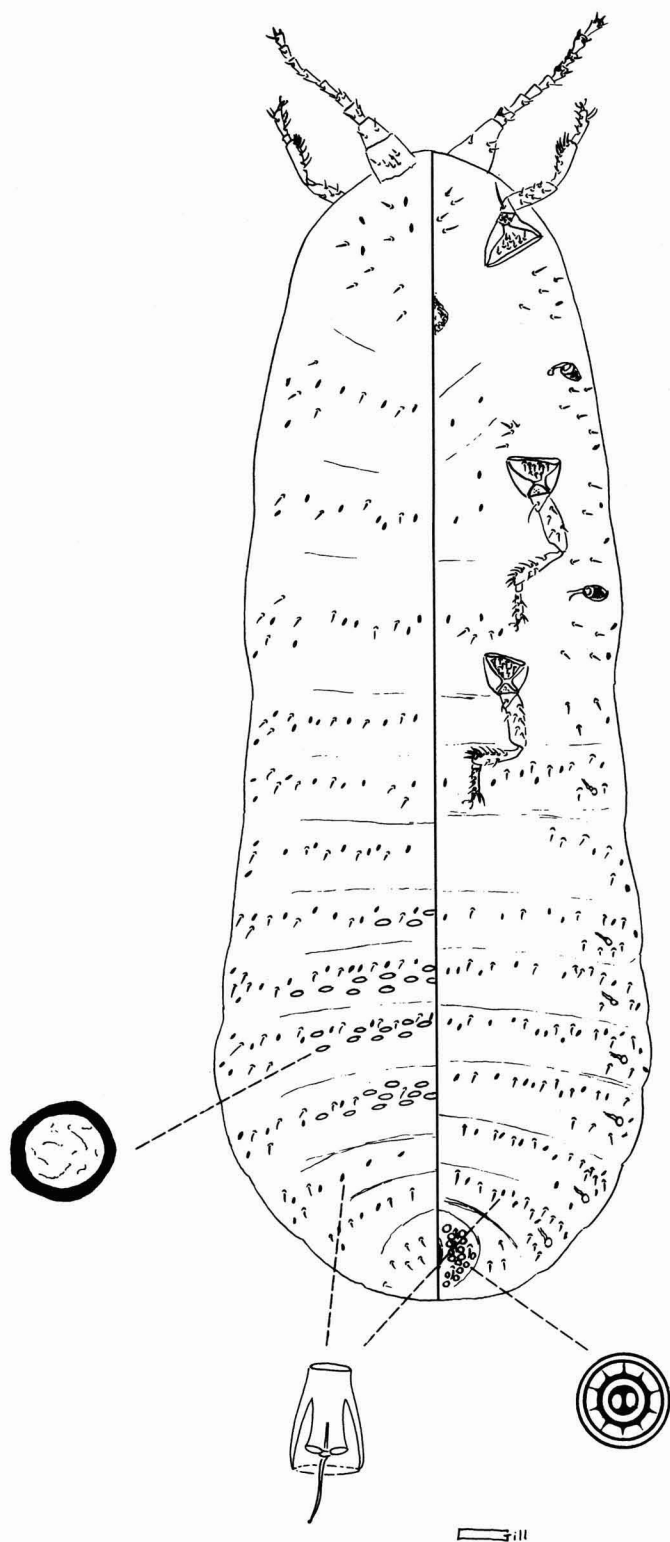


Fig. 24: *Matsucoccus californicus* Morrison.

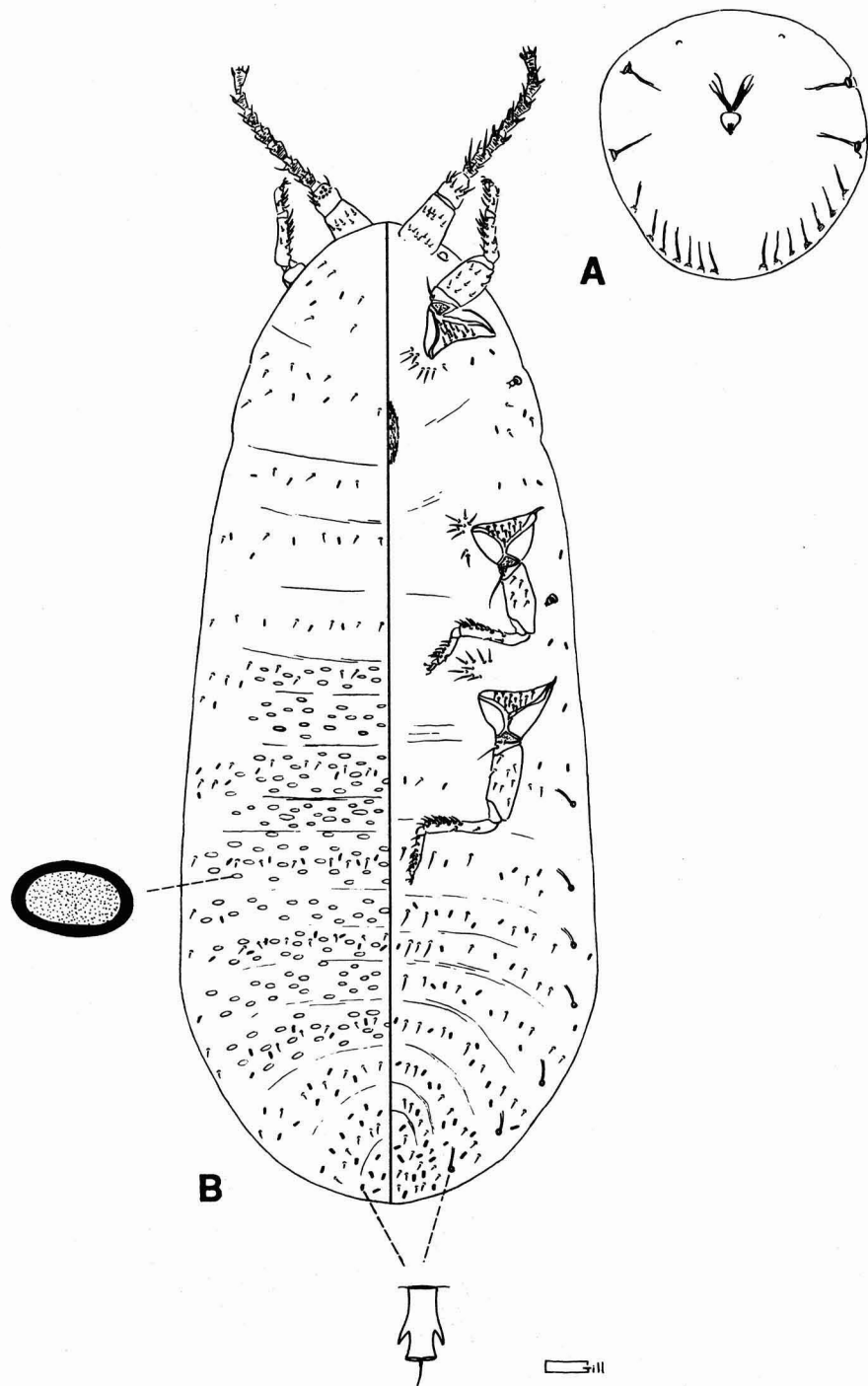


Fig. 25: *Matsucoccus fasciculensis* Herbert. A. nymph. B. adult female.

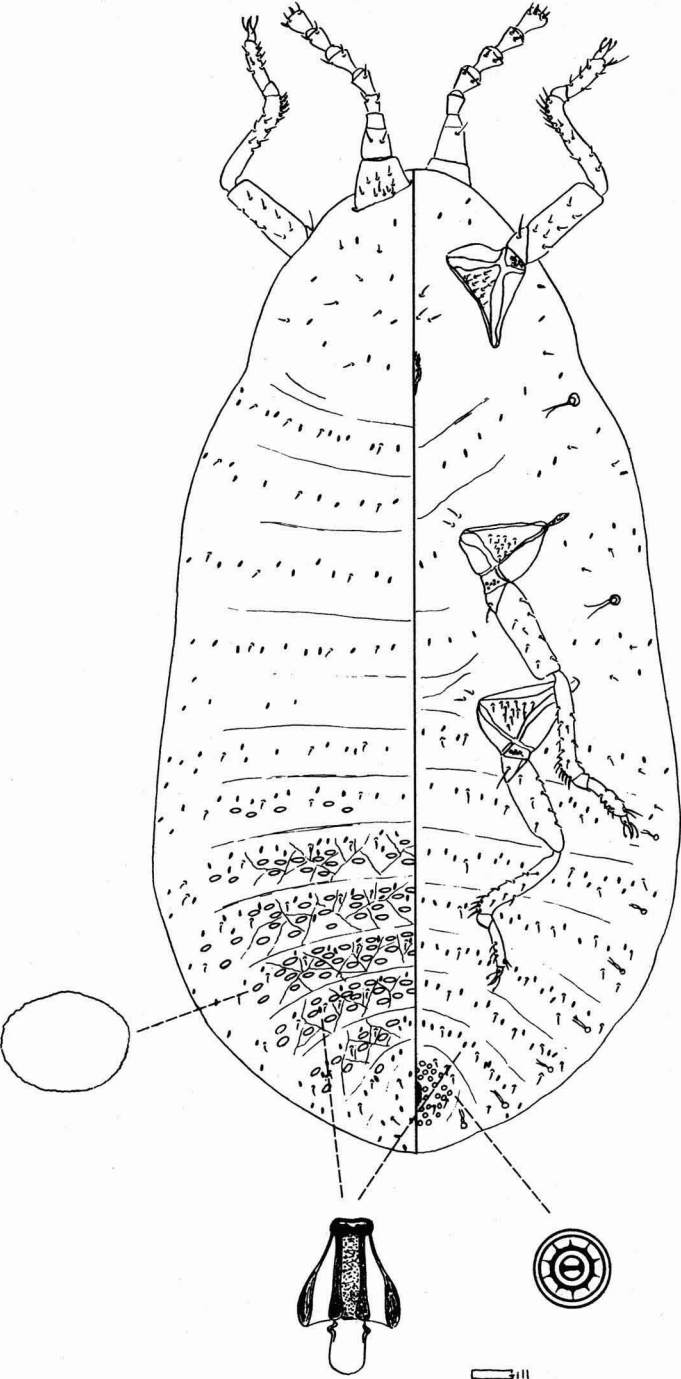


Fig. 26: *Matsucoccus monophyllae* McKenzie.

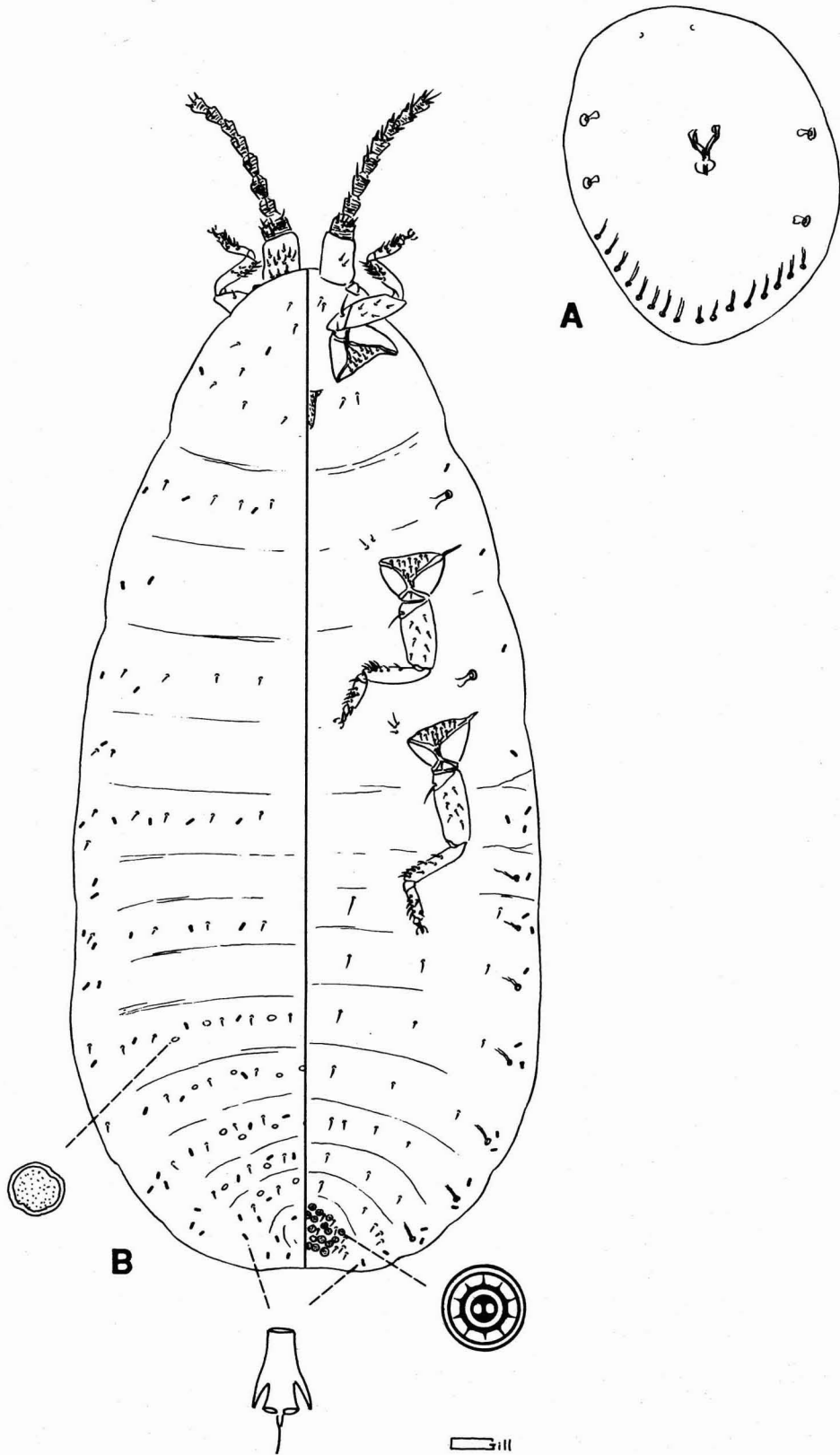


Fig. 27: *Matsucoccus paucicatrices* Morrison. A. nymph. B. adult female.

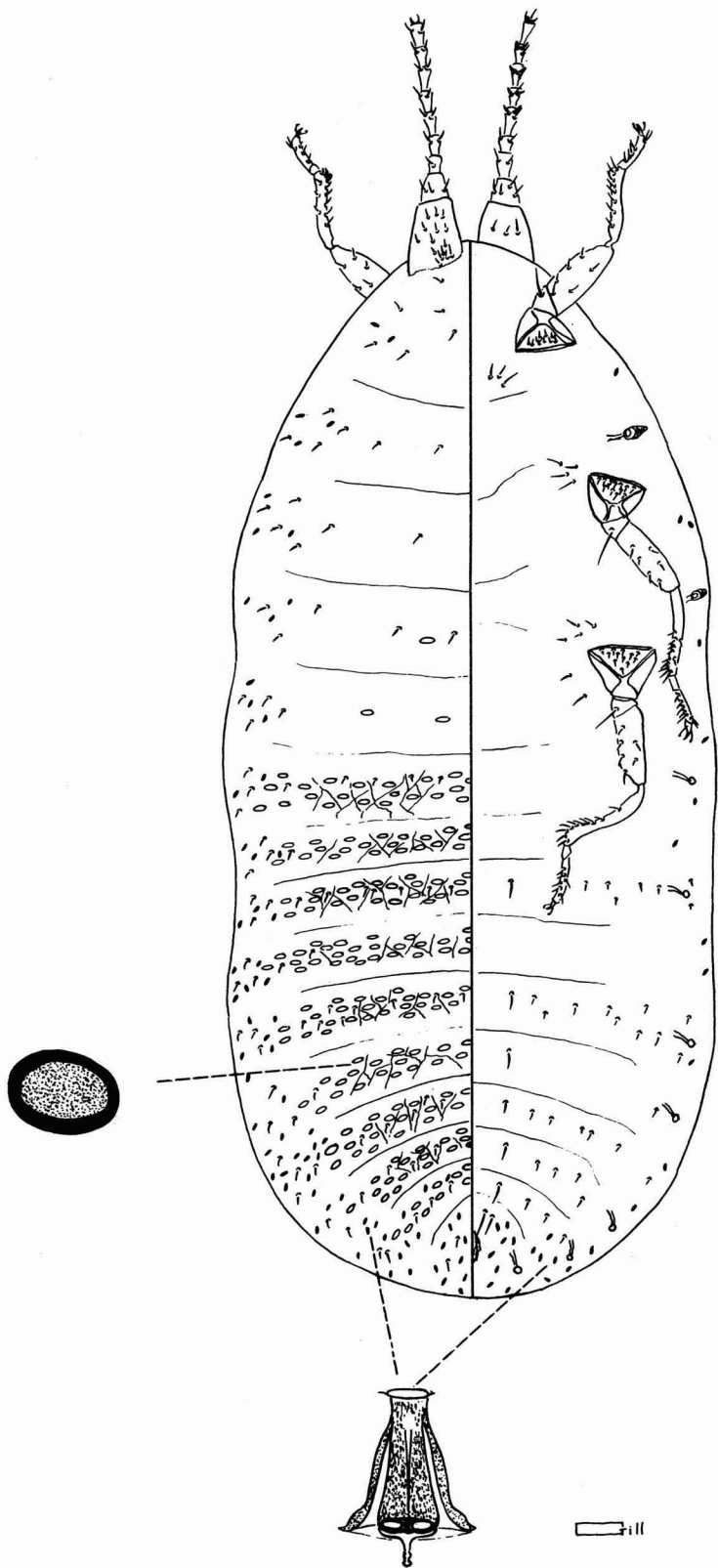


Fig. 28: *Matsucoccus secretus* Morrison.

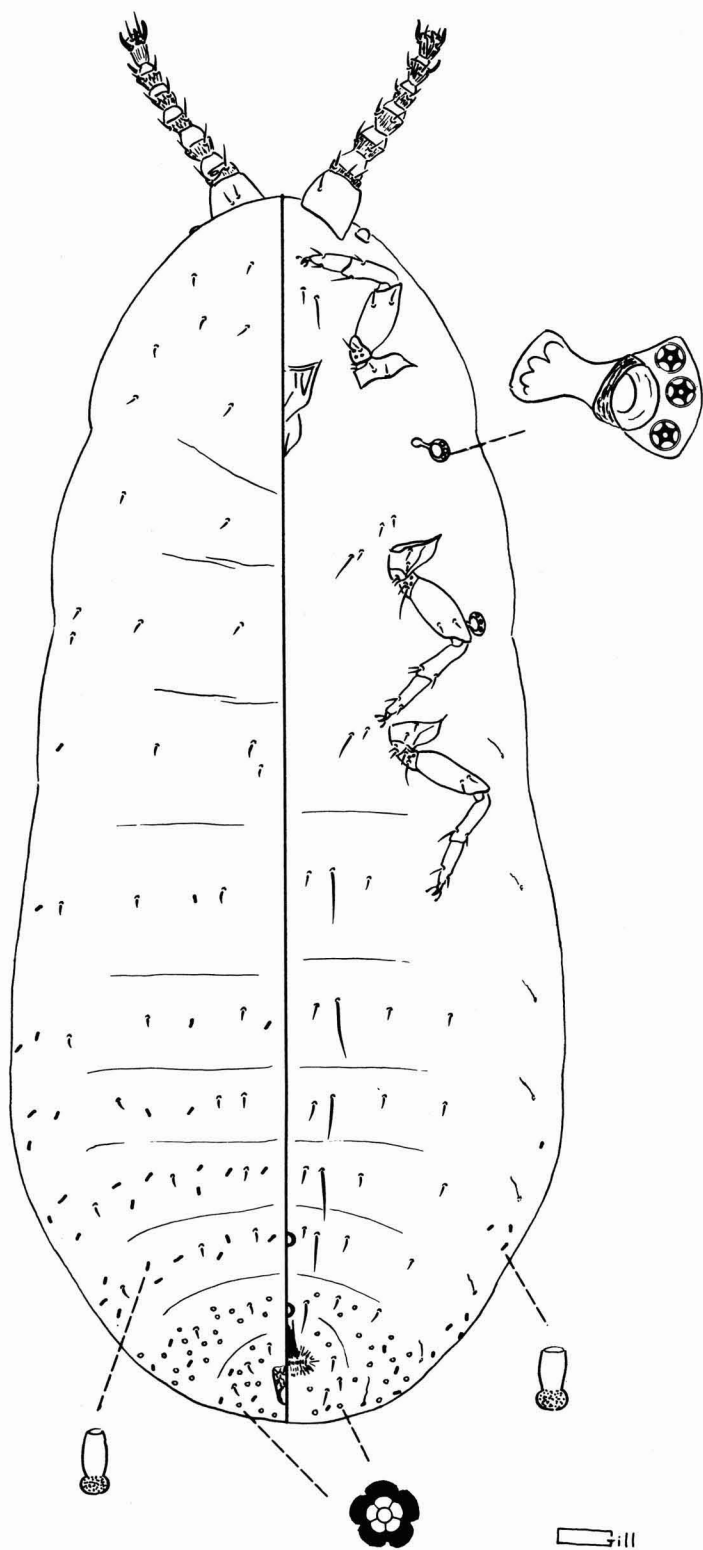


Fig. 29: *Pityococcus deleari* McKenzie.

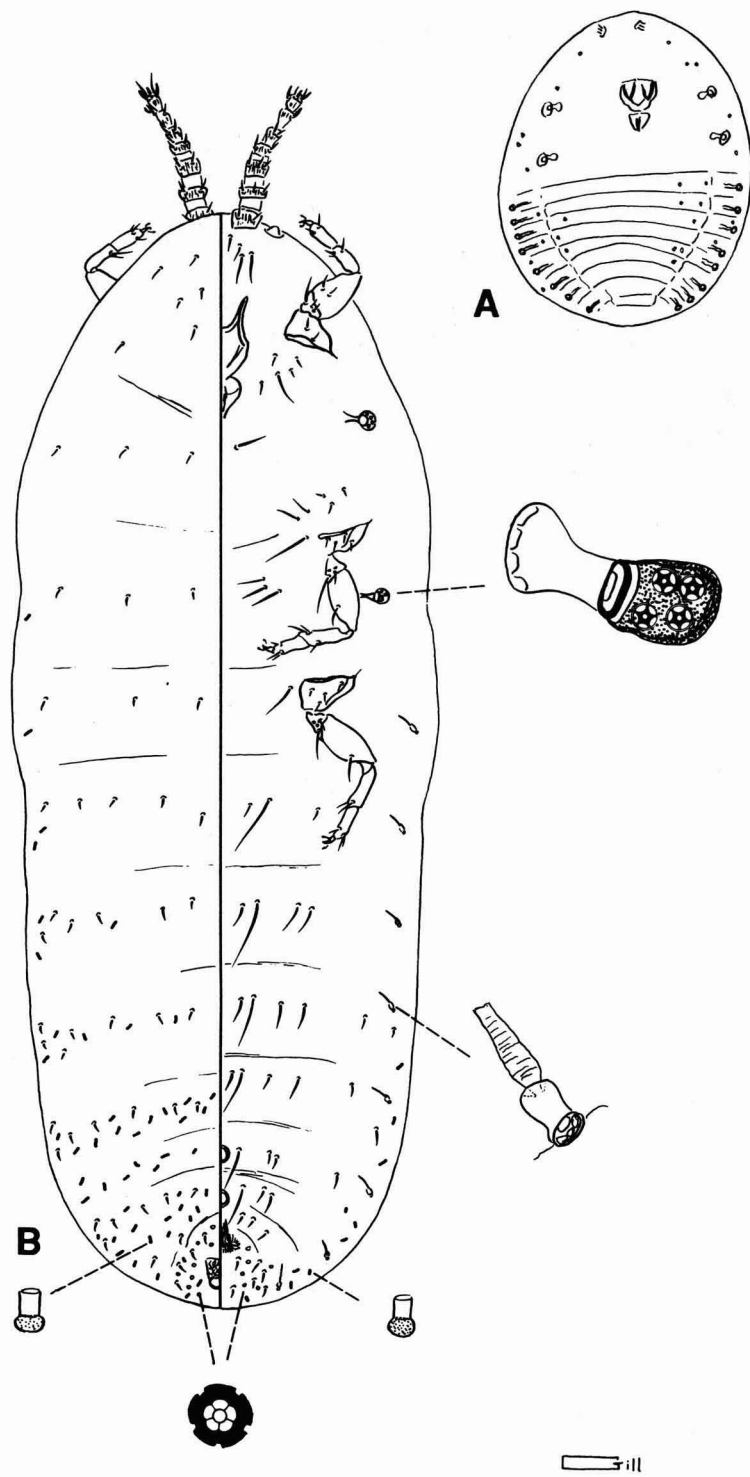


Fig. 30: *Pityococcus ferrisi* McKenzie. A. nymph. B. adult female.

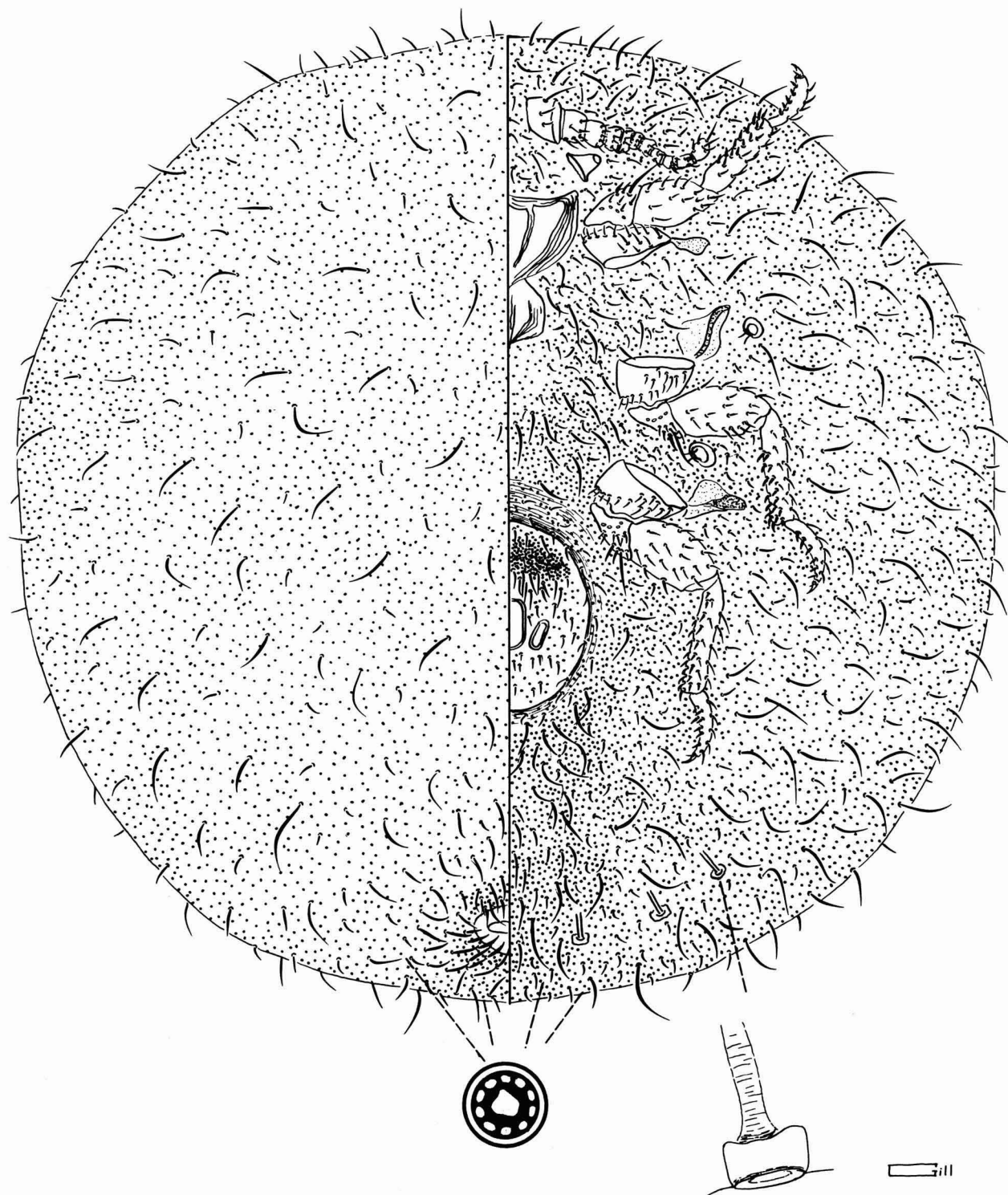


Fig. 31: *Steatococcus townsendi* (Cockerell).

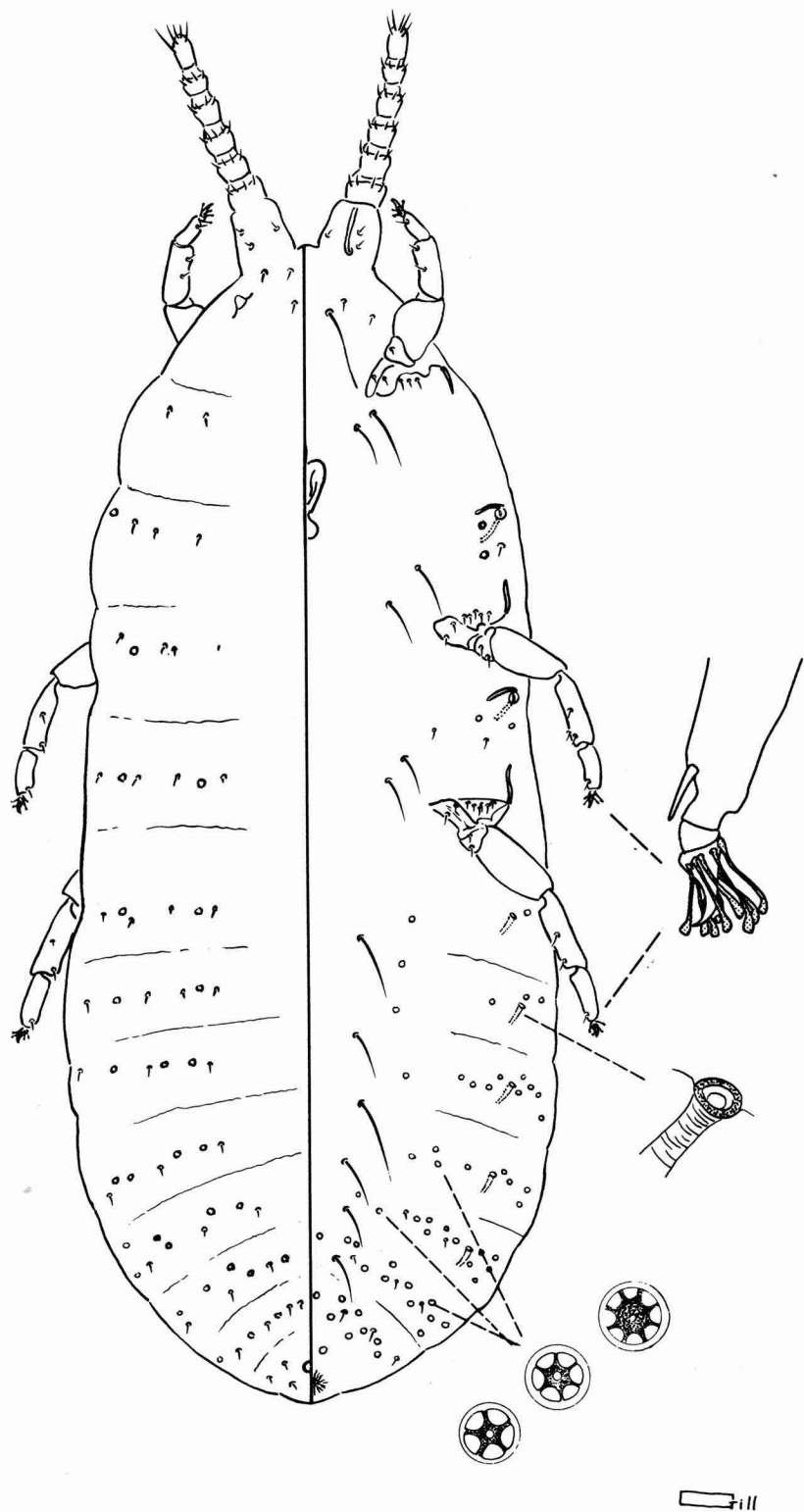
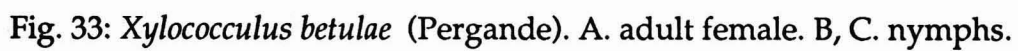


Fig. 32: *Stomacoccus platani* Ferris.



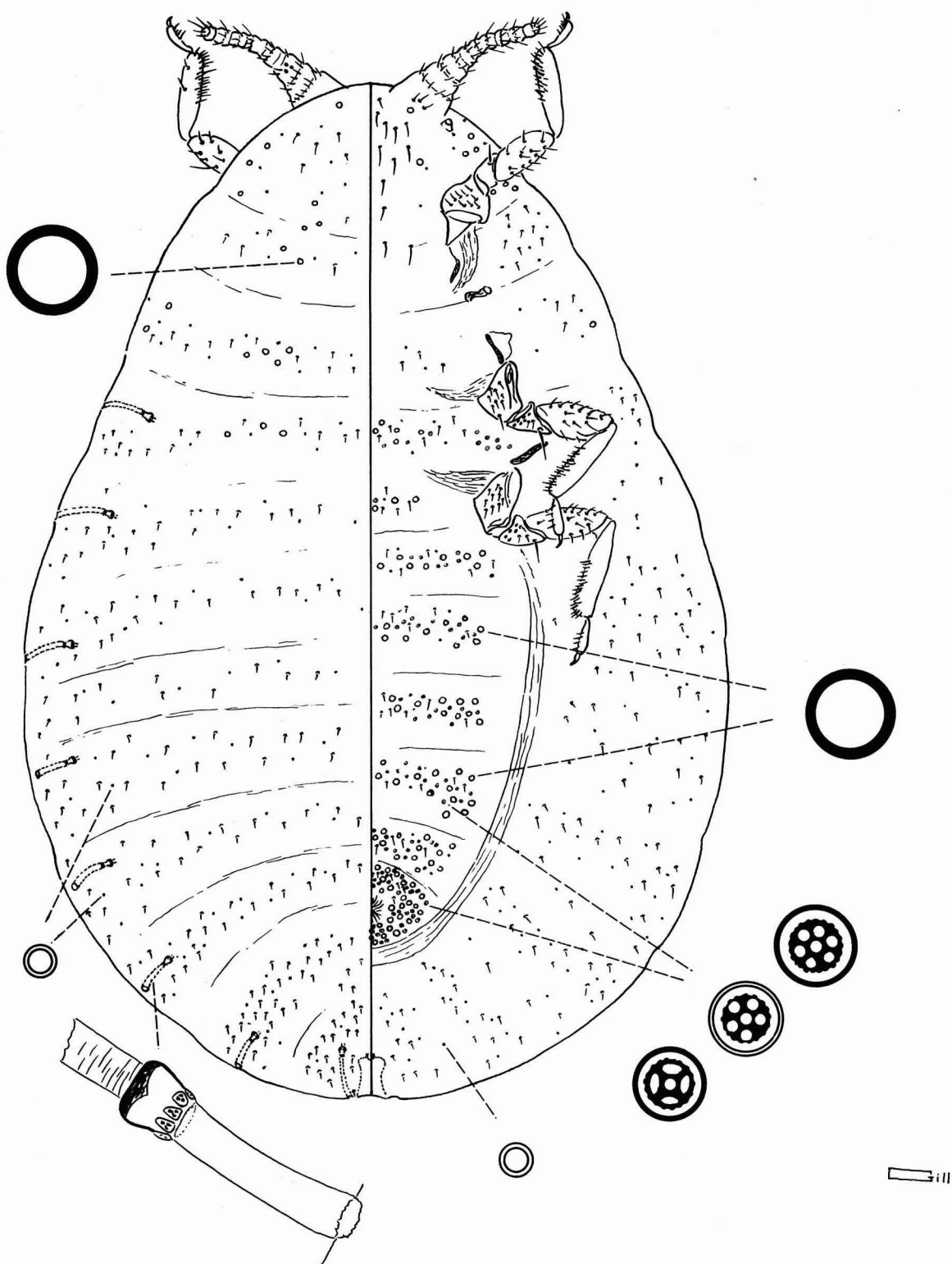


Fig. 34: *Xylococcus macrocarpae* (Coleman), adult female.

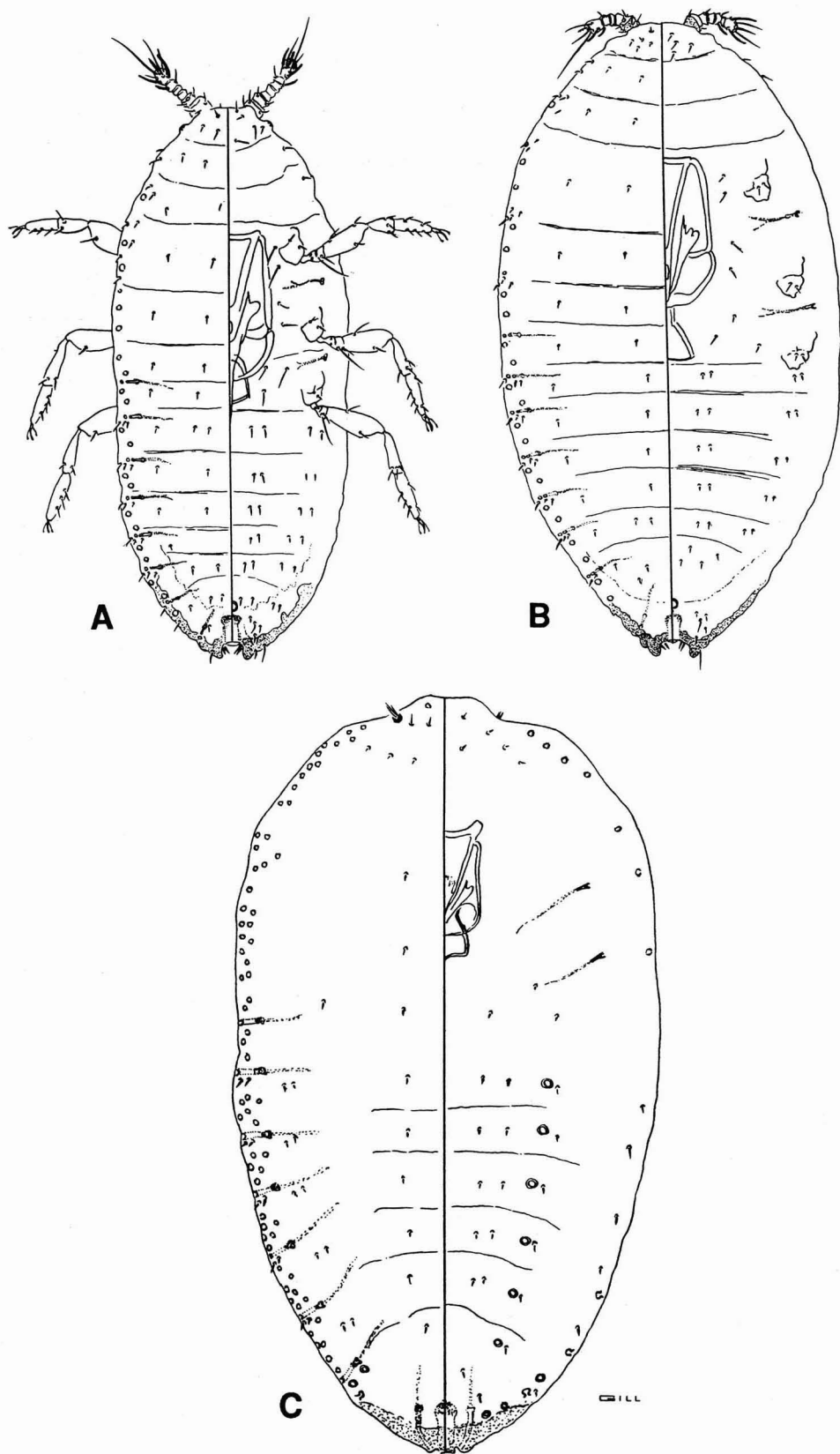


Fig. 35: *Xylococculus macrocarpae* (Coleman), first and second instar females:
A. Crawler. B. Settled crawler. C. Second instar.

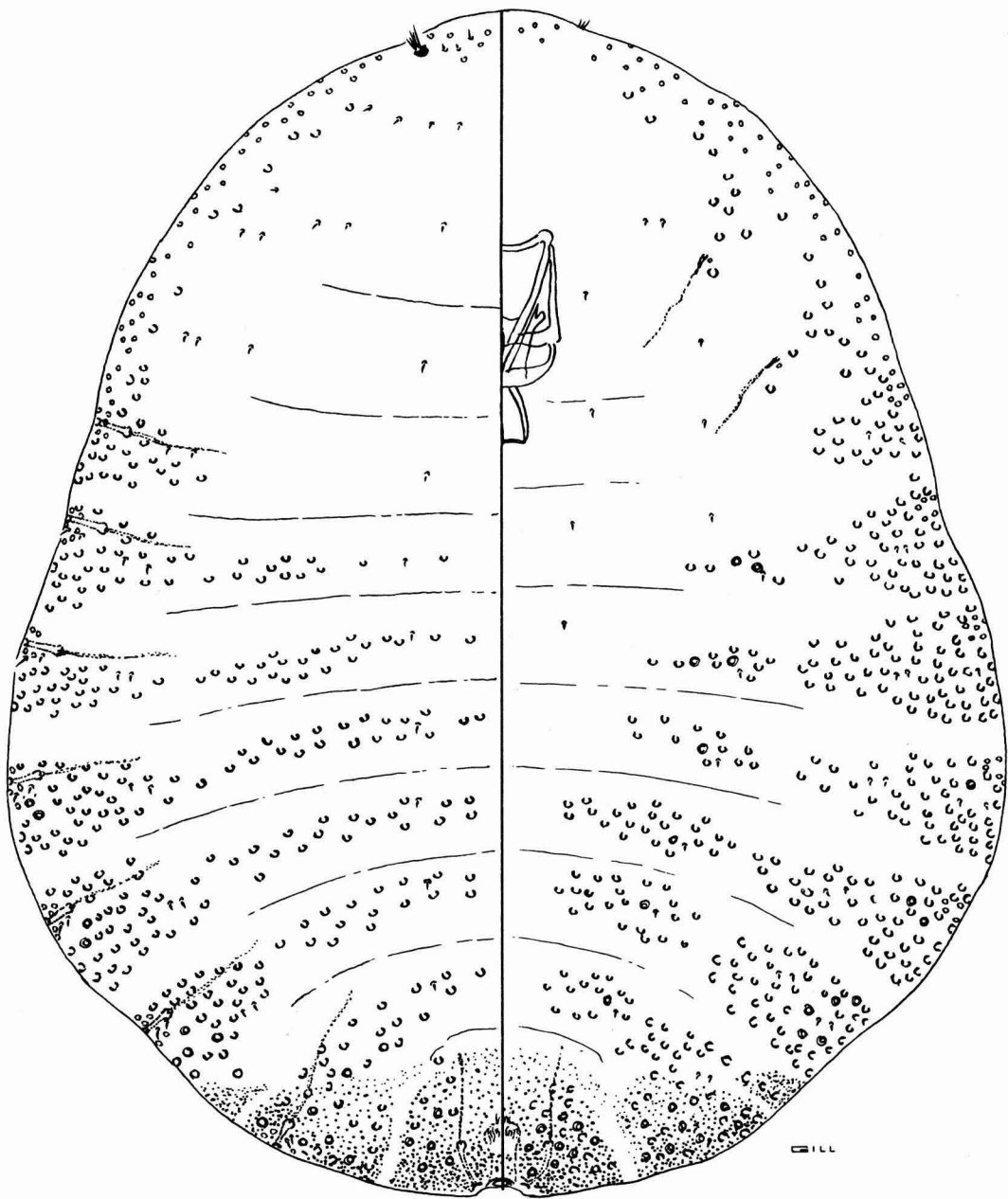


Fig. 36: *Xylococcus macrocarpae* (Coleman), third instar female.

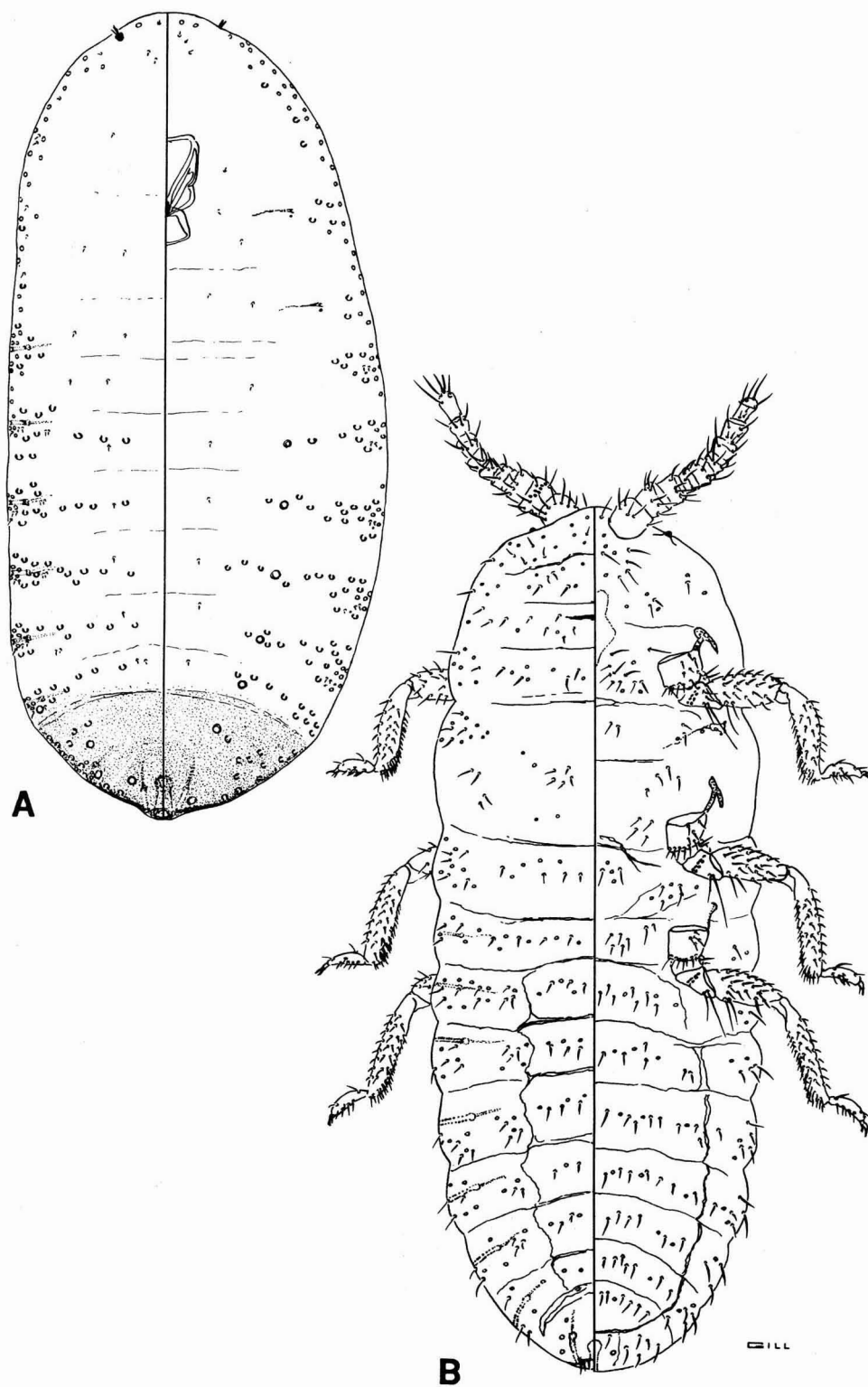


Fig. 37: *Xylococcus macrocarpae* (Coleman), second and third instar males:
A. Second instar. B. Prepupa.

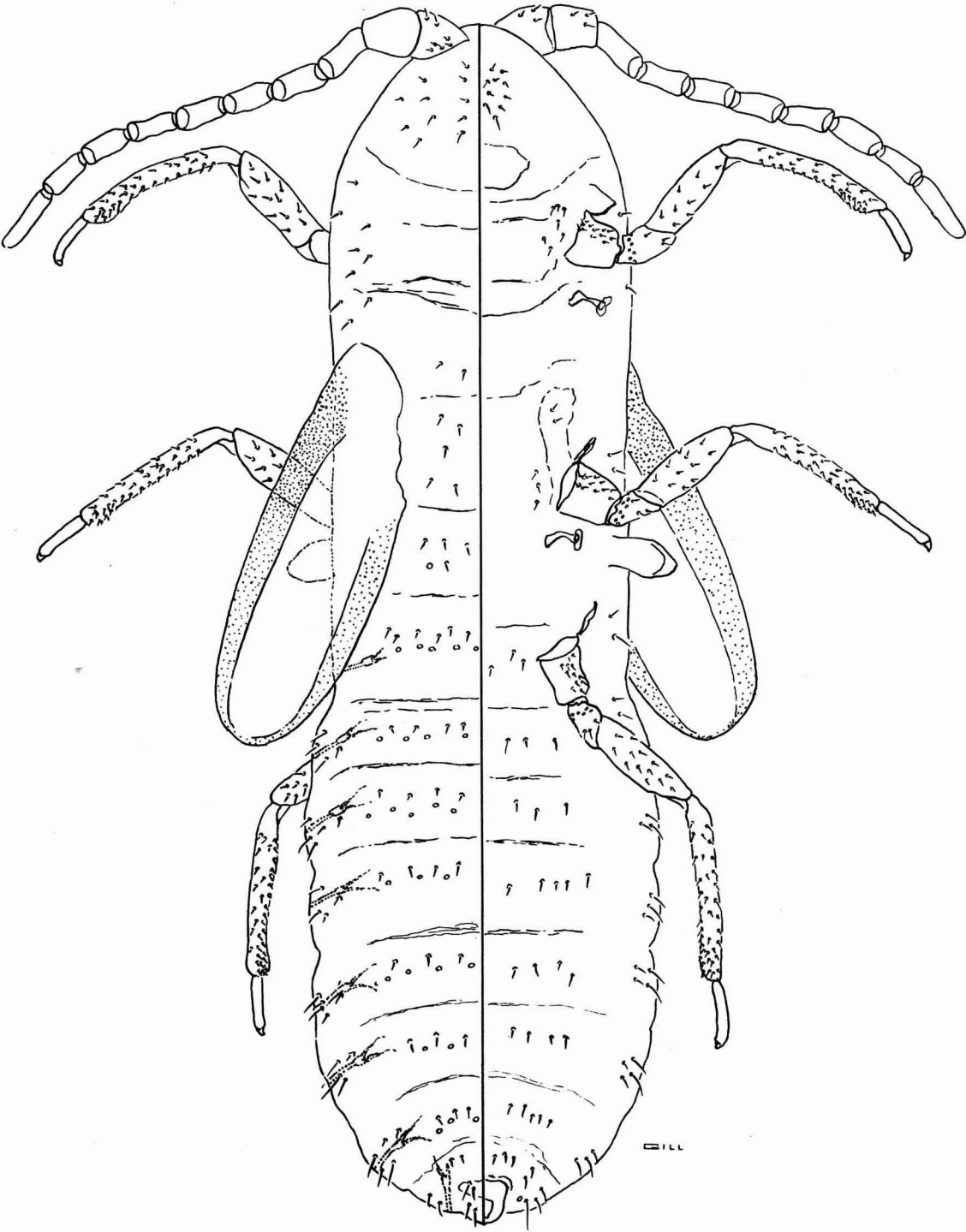


Fig. 38: *Xylococcus macrocarpae* (Coleman), pupal male.

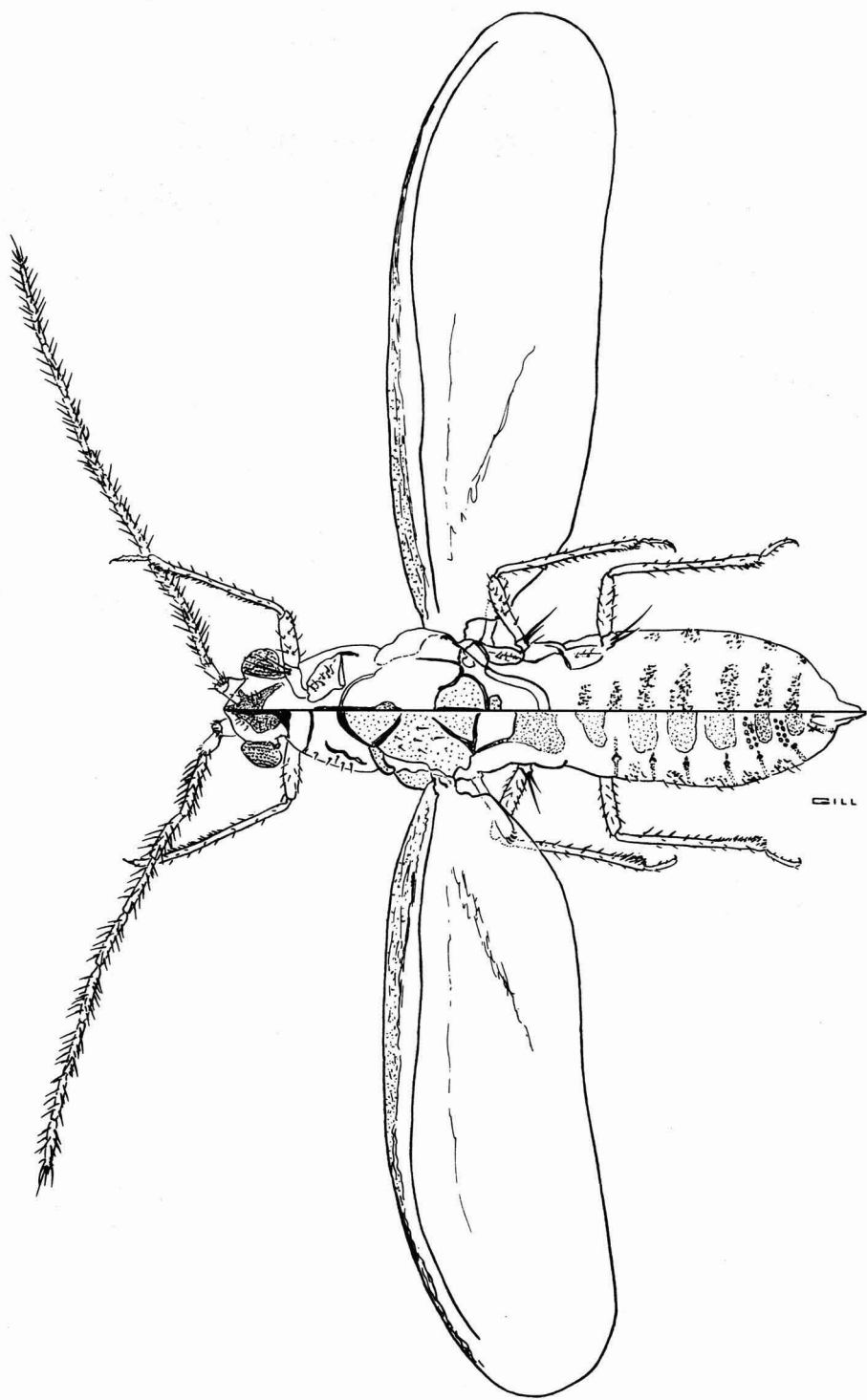


Fig. 39: *Xylococcus macrocarpae* (Coleman), adult male.

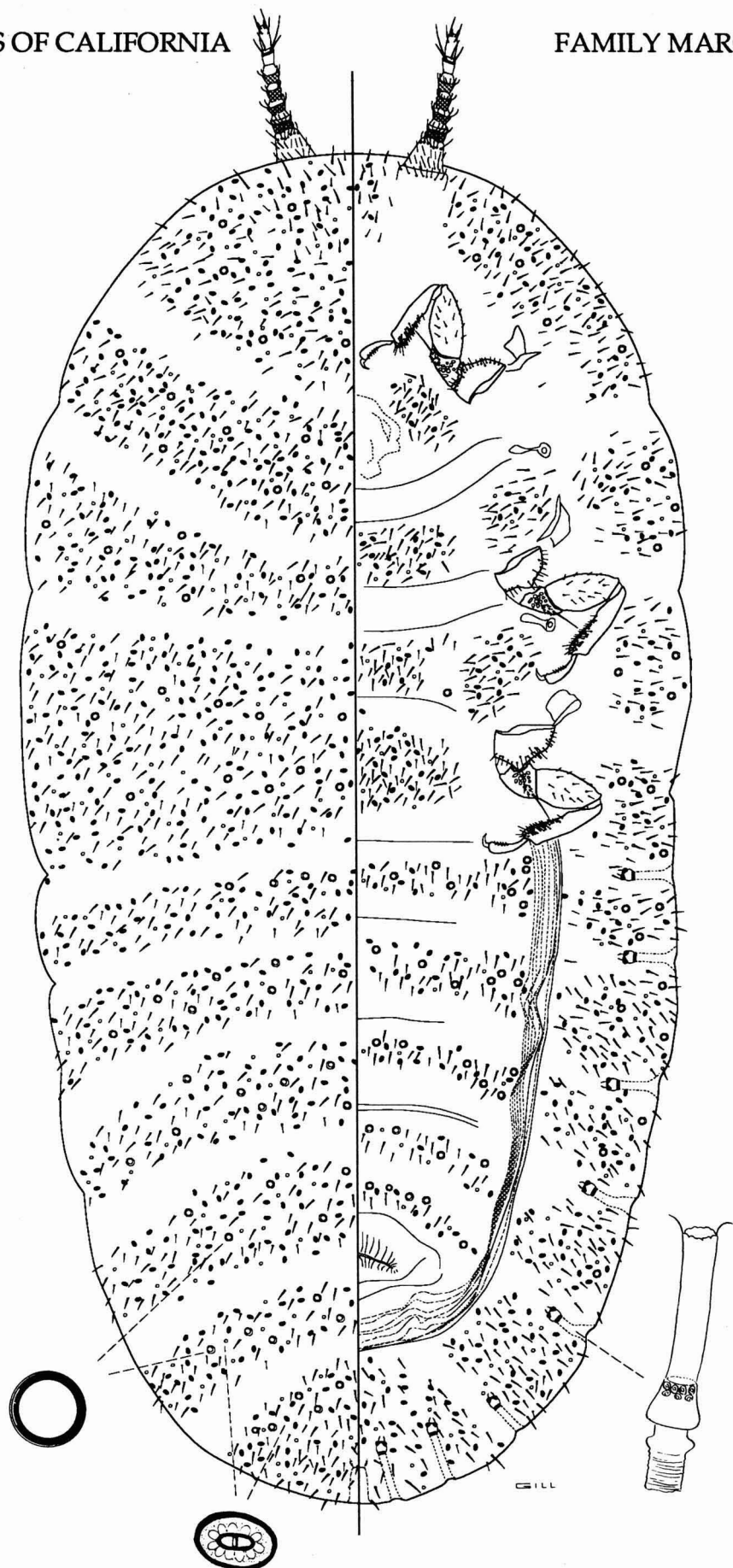


Fig. 40: *Xylococcus quercus* (Ehrhorn).

FAMILY ORTHEZIIDAE

ensign scales

Color Plates 34-42

This family contains only five genera, two of which occur in California. The flag-like ovisac of the females is responsible for the common name "ensign scale." The characteristics of the California species are typical of the group and should allow easy recognition to family level.

Field Characteristics: The distinctive features of the group are the dorsal and marginal white wax plates arranged in various patterns; the large, slightly-flattened eggsac, which may reach well over twice the length of the body; and the long appendages. Nymphs are normally similar to the adults but lack the ovisac. Unlike most other scale insects which form an ovisac, the ensign scales are capable of carrying the ovisac around with them. Species or genera may be recognized in the field in certain circumstances, particularly if one is aware of host plant preferences of the various species. The following field key utilizes this concept:

Field Key to California Ortheziidae

1. With triangle-shaped wax plates on median areas of the three thoracic segments (the two species cannot be field identified) Color Plate 34 *Arctorthezia*
— With transverse, elongate wax plates on median areas of the three thoracic segments (*Orthezia*), Color Plates 35-42 2
2. Much of dorsum devoid of wax plates except along midline and along body margin, the brownish or purplish body readily visible between the wax plates 3
— Dorsum usually completely covered by wax plates 4
3. Host plants usually subtropical ornamentals *Orthezia insignis*
— Hosts usually grasses *Orthezia graminis-monticola* complex
4. Species found on the following hosts:
 - a. *Atriplex* *Orthezia annae*
 - b. *Artemisia* *Orthezia artemisiae*
 - c. *Sarcobatus*. *Orthezia sarcobati*
 - c. *Rubus*. *Orthezia newcomberi*

Similar Species: Cottonycushion scale (*Icerya purchasi*) and other large margarodids and mealybug genera such as *Puto* and *Nipaecoccus* are all similar in field appearance.

Hosts: In California this family feeds primarily on native hosts. See individual species accounts. One introduced species, *Orthezia insignis*, feeds on a wide range of ornamental hosts.

Economic Importance: One or two species in the family worldwide occasionally cause injury. Only one species with economic potential, *Orthezia insignis*, occurs in California. See comments under that species.

Distribution: Members of the group are rarely collected in California because they occur mostly in areas of extensive native vegetation rather than in cultivated areas, because they are

secretive in habit and because several species are found most often on roots, in ant nests or under rocks.

Representatives of the family can be found throughout the state, although some species are restricted in their range. Many species occur in the southwestern United States, and while most of them have not yet been recorded from California some of them may be found here eventually. For example, *Orthezia sarcobati* Morrison has been recorded from Beatty, Nevada, about 10 miles from the California border. It probably occurs in the Death Valley area.

Diagnosis: Ortheziids are separated from other scale families because they have abdominal spiracles, a well-developed anal ring with pores and setae, and stalked eyes. Margarodids have abdominal spiracles but have a simple anal ring with no pores or setae and the eyes are not stalked.

Morrison (1925, 1952) has done much toward furthering our knowledge of this group worldwide. However, our understanding of some of the forms known from the southwest is still inadequate. The range of variation between species is not known at this time, partly because they are so seldom collected, and the actual significance of some morphological characters used by Morrison, such as sclerotization of the median areas of the head and the number of spiracles, may require re-evaluation. Sense organs of the ortheziid antennae have been thoroughly studied by Rosciszewska (1989). The morphology of the adult males has been studied by Koteja (1986).

The ortheziids are hard to work with because the derm is usually so thoroughly covered with spines that other important structures are difficult to discern. Also it is difficult to obtain quality slide preparations of these insects.

The wax plates should be removed from specimens either by carefully manipulating them with spatulas or by placing specimens for a time in xylene before they are placed in KOH, Essig's aphid fluid or other clearing reagents. THF is not an adequate wax solvent for these species and the wax must be removed before they are cleared. If the wax is left on the specimens during clearing, it greatly interferes with this process and the wax becomes much more difficult to remove.

A checklist and key to the California species, their host plants, distribution, and illustrations are given, but only two species, *Orthezia annae* and *O. insignis*, are dealt with in detail. For further information on morphology, distribution, and host plants, see Morrison (1925, 1952). The two papers by Morrison are extremely useful when studying the ortheziids, and it is necessary to have both papers in hand when working on ortheziid identifications.

Koteja, J., 1986: Polskie Pismo Entomol. 56:323-374.

Morrison, H., 1925: J. Agric. Res. 30(2):97-154.

Morrison, H., 1952: U.S. Dep. Agric. Tech. Bull. 1052:1-180.

Rosciszewska, M., 1989: Acta. Biolog. Cracoviensia Ser. Zool. 31:1-17.

Morphological Key to California Ortheziidae

1. Median dorsal thoracic spine clusters triangular; with a pore band within the opening of the thoracic spiracles. 2
- Median thoracic spine clusters transverse; without a pore band in the opening of the thoracic spiracles. 3
2. Dorsal marginal pores arranged in circular groups. . . . *Arctorthezia pseudoccidentalis*
- Dorsal marginal pores not arranged in circular groups *Arctorthezia occidentalis*
3. Dorsal spine clusters reduced to narrow bands on median and submarginal areas . . 4
- Dorsal spine clusters usually little reduced, completely covering dorsum 5
4. Spines completely absent within the ovisac band. *Orthezia insignis*
- With 4-6 rows of spines within the ovisac band. *Orthezia graminis*
5. Median area of head with a sclerotized band. 6
- Median area of head without sclerotization 7
6. With seven abdominal spiracles *Orthezia artemisiae*
- With eight abdominal spiracles *Orthezia sarcobati*
7. Spines in spine collar around thoracic spiracle opening much shorter than other body spines *Orthezia annae*
- Spines in spine collar around thoracic spiracles about the same length as body spines *Orthezia newcomberi*

CALIFORNIA SPECIES OF ORTHEZIIDAE

Genus *Arctorthezia* Cockerell, 1902

Number of North American species: 3.

Arctorthezia occidentalis (Douglas), 1891
western ensign scale

Fig. 41, Color Plate 34

Synonymy:
Orthezia californica Ehrhorn, *Orthezia occidentalis* Douglas.

Hosts: Mostly grass roots; also *Eriophyllum*.
Distribution: Western United States; common in San Francisco Bay area.

Arctorthezia pseudoccidentalis Morrison, 1952
subterranean ensign scale

Fig. 42

Hosts: Grass roots, duff; frequently found under rocks. Common in the coast range north of San Francisco to Trinity County; also in the Sierra Nevada

Distribution: Western United States; common and in San Bernardino County.

Genus *Orthezia* Bosc D'Antic, 1784

Number of world species: Approximately 51.

Number of North American species: 24.

Key to the world species: Morrison (1925 and 1952).

Orthezia annae Cockerell, 1893
atriplex ensign scale

Fig. 43, Color Plates 35, 36

Field Characteristics: Pure white to greyish; body 2.5 to 3.0 mm long; total length with ovisac to 8.0 mm. Dorsal surface and margins densely covered by wax plates. The ovisac in many individuals curls upward as it gets longer.

Biology: Unknown.

Similar Species: Cottonycushion scale and various species of ortheziids.

Hosts: Shad scales (*Atriplex*) and other plants in the Chenopodiaceae.

Economic Importance: A native species of no economic significance due to its restricted

host preferences. A rather unusual outbreak of this species occurred on *Atriplex* in the Palo Verde Valley of Riverside County in 1967, possibly as a result of pesticide applications for pink bollworm on cotton.

Distribution: Very common on *Atriplex* from the southern San Joaquin Valley south to Mexico and east to Texas.

Diagnosis: The lack of sclerotization on the dorso-medial area of the head, the reduced spines around the openings of the thoracic spiracles and the six-segmented antennae of the nymphs distinguish this species.

Orthezia artemisiae Cockerell, 1898
artemisia ensign scale

Fig. 44, Color Plates 37, 38

Other Common Names: sage orthezia.

Hosts: Primarily *Artemisia*.

Distribution: Southern California, Modoc County, Lassen County, Washington, Idaho, New Mexico (see Furniss & Barr, 1975).

Furniss, M. M. and W. F. Barr, 1975: U.S. For. Serv. Gen. Tech. Bull. INT-19:1-64.

Orthezia graminis Tinsley, 1898
grass ensign scale

Hosts: Grasses.

Distribution: Recorded from Lancaster, Los Angeles County (See Diagnosis).

Diagnosis: Ferris (1919a) lists *graminis* from Lancaster in the desert area of Los Angeles County. However, his specimens have been examined and they are much closer morphologically to *Orthezia monticola* Cockerell than to *graminis*. Therefore, these ortheziids will be referred to here as the *graminis-monticola* complex until their true identity can be ascertained. A morphological illustration will not

be provided because of the uncertainty of the specific identification. Specimens in this complex are also known from Westgaard Pass, Inyo County.

Ferris, G. F., 1919a: A contribution to the knowledge of the Coccidae of the southwestern United States. Stanford Univ. Publ., Univ. Ser. 68 pp.

Orthezia insignis Brown, 1887
greenhouse orthezia

Fig. 45, Color Plate 39

Other Common Names:

Kew bug, lantana bug, marsupial coccid, lantana blight.

Field Characteristics: Body to 1.25 mm long; total length including ovisac 3.0 mm. One of the smallest of the California ensign scales. Distinct from most other California ensign scales because large areas of the dorsum are free of wax plates. Thus the dark-brown body can be seen, giving the species a bicolored appearance. Dorsal white wax is restricted to a marginal fringe and a band running lengthwise along the back.

Biology: Apparently unknown in California. According to Epila (1986a), has multiple yearly generations in Africa. For information on general biology, feeding behavior and methods of infestation see Epila (1986b) and Ezzat (1956).

Similar Species: Adults of this species resemble other ensign scales but other California species have the dorsum almost com-

pletely covered by wax plates. *Orthezia nigrocincta* Cockerell, *O. monticola* Cockerell from New Mexico, and *O. pseudinsignis* Morrison from Mexico and South America are similar to *O. insignis* in that the dorsum is largely free of wax plates, but they do not occur in California. *O. graminis* Tinsley has two longitudinal dorsal bands which are free of wax, but these bands are much narrower than those of *insignis*. Immature ensign scales resemble mealybugs and putoids.

Hosts: Prefers *Lantana* in California. Also attacks *Citrus* and a number of ornamental hosts. For a host list, see Merrill (1953) and Essig (1958).

Economic Importance: Has been a serious pest in greenhouses in various parts of the world. A pest of importance outdoors in some tropical countries. Thus far not a serious pest in California. For more information, see Zimmerman (1948).

Distribution: Found outdoors along the coast

from San Diego north to Santa Barbara. Has been found throughout the state on indoor ornamental plants. Elsewhere, found almost worldwide on greenhouse plants; tropicopolitan outdoors.

Diagnosis: The reduced spine pattern on the dorsum, lack of spine bands inside the ovisac band, small size, and host plant preference distinguish this species. *Orthezia nigrocincta* from New Mexico has reduced dorsal spine bands, but has spine bands ventrally within the ovisac spine band. *O. pseudinsignis* from Mexico and South America is identical to *O. insignis* but the derm is heavily sclerotized on the median areas of the head and thorax.

Epila, J. S. O., 1986a: Insect Sci. Applic. 7:53-59.

Epila, J. S. O., 1986b: Insect Sci. Applic. 7:61-67.

Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.

Ezzat, Y. M., 1956: Bull. Entomol. Soc. Egypte 40:415-431.

Merrill, G. B., 1953: Fla. State Plant Board Bull. 1:1-143.

Zimmerman, E. C., 1948: Insects of Hawaii, Vol. 5, Homoptera: Sternorrhynca. Univ. Hawaii Press, Honolulu. 464 pp.

***Orthezia newcomberi** Morrison, 1952**
Newcomber's ensign scale

Fig. 46, Color Plate 40, 41

Hosts: Caneberries (*Rubus*).

Distribution: Sacramento Valley.

*Actual California identifications are in

doubt. They have been labeled as "probably this species" by Harold Morrison.

***Orthezia sarcobati* Morrison, 1952**
sarcobatis ensign scale

Fig. 47, Color Plate 42

Hosts: *Sarcobatus*.

Distribution: Death Valley and east of the Sierra Nevada, California; Beatty, Clark County, Topaz Lake, Douglas County, and

Patrick, Washoe County, Nevada; Arizona; Utah. California localities are only probable, as yet not officially collected in the State.

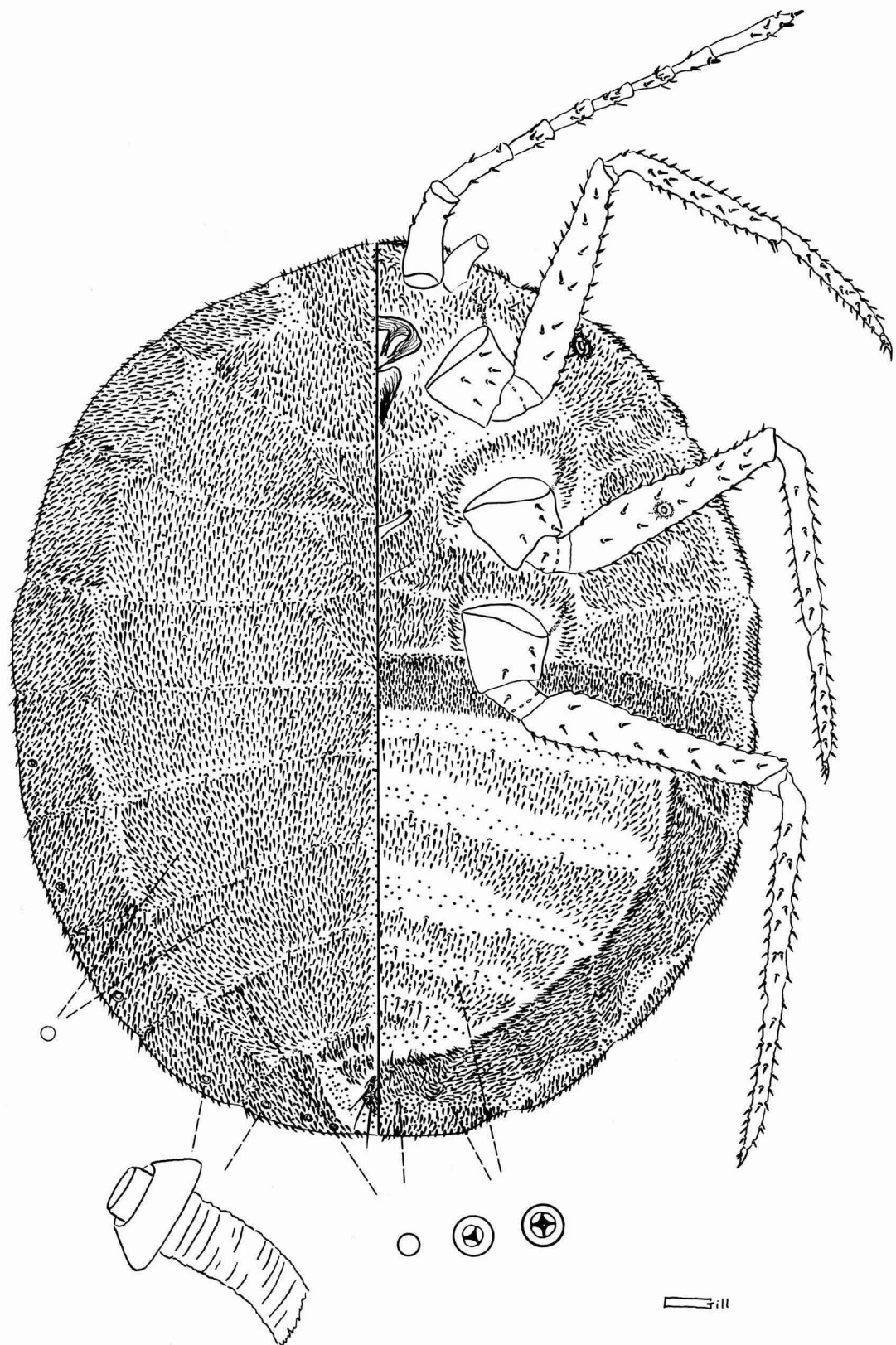


Fig. 41: *Arctorthezia occidentalis* (Douglas).

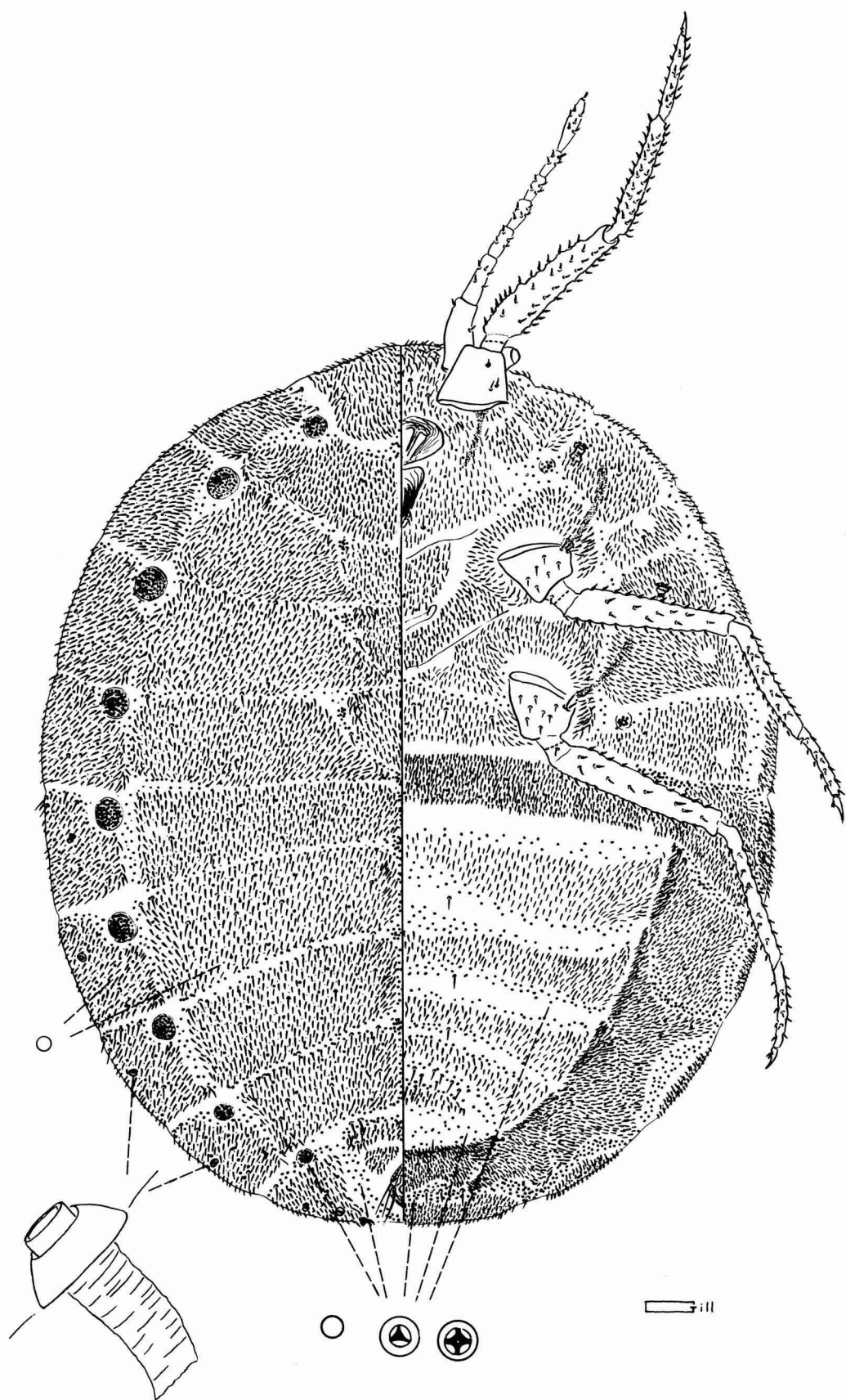


Fig. 42: *Arctorthezia pseudoccidentalis* Morrison.

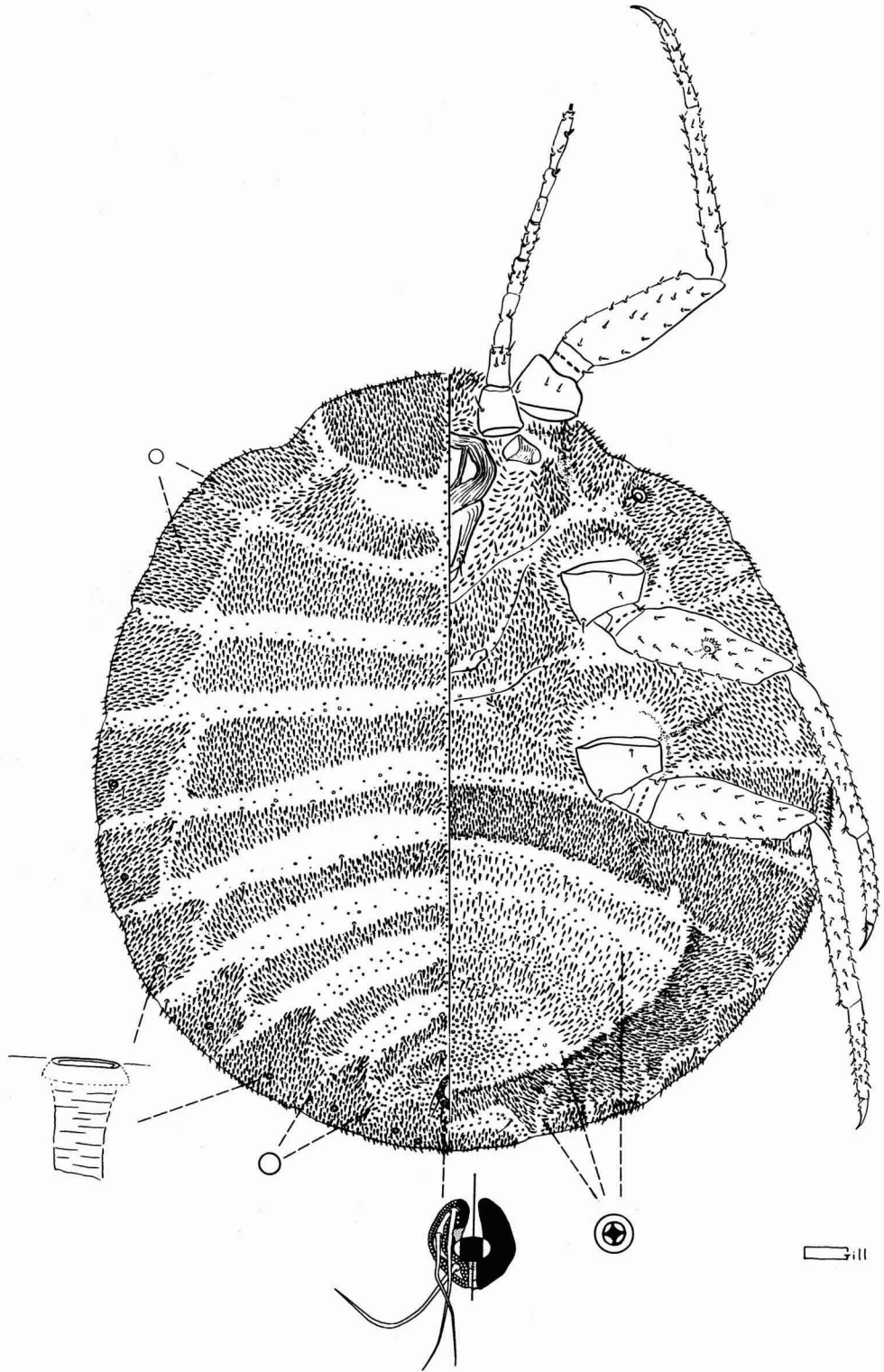


Fig. 43: *Orthezia annae* Cockerell.

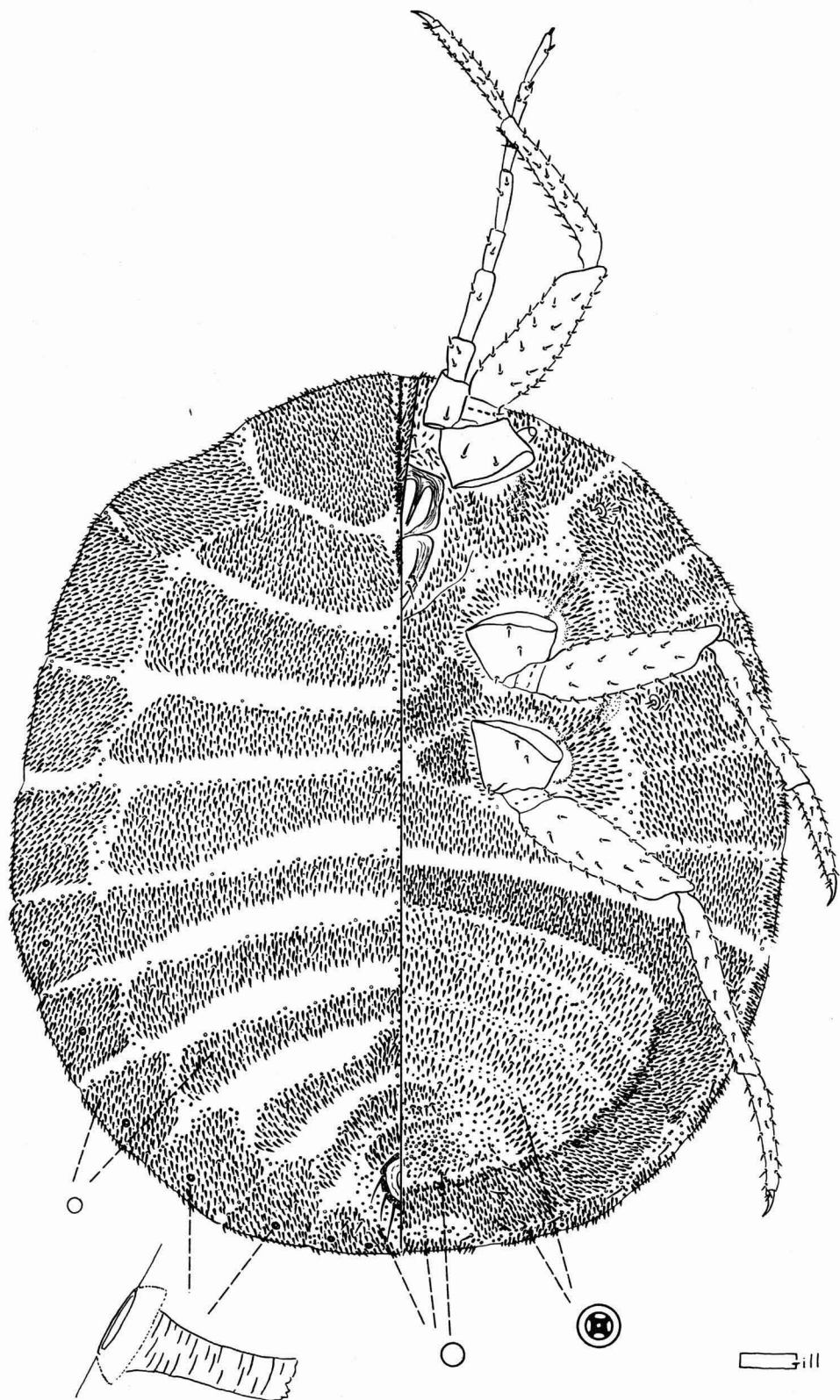


Fig. 44: *Orthezia artemisiae* Cockerell.

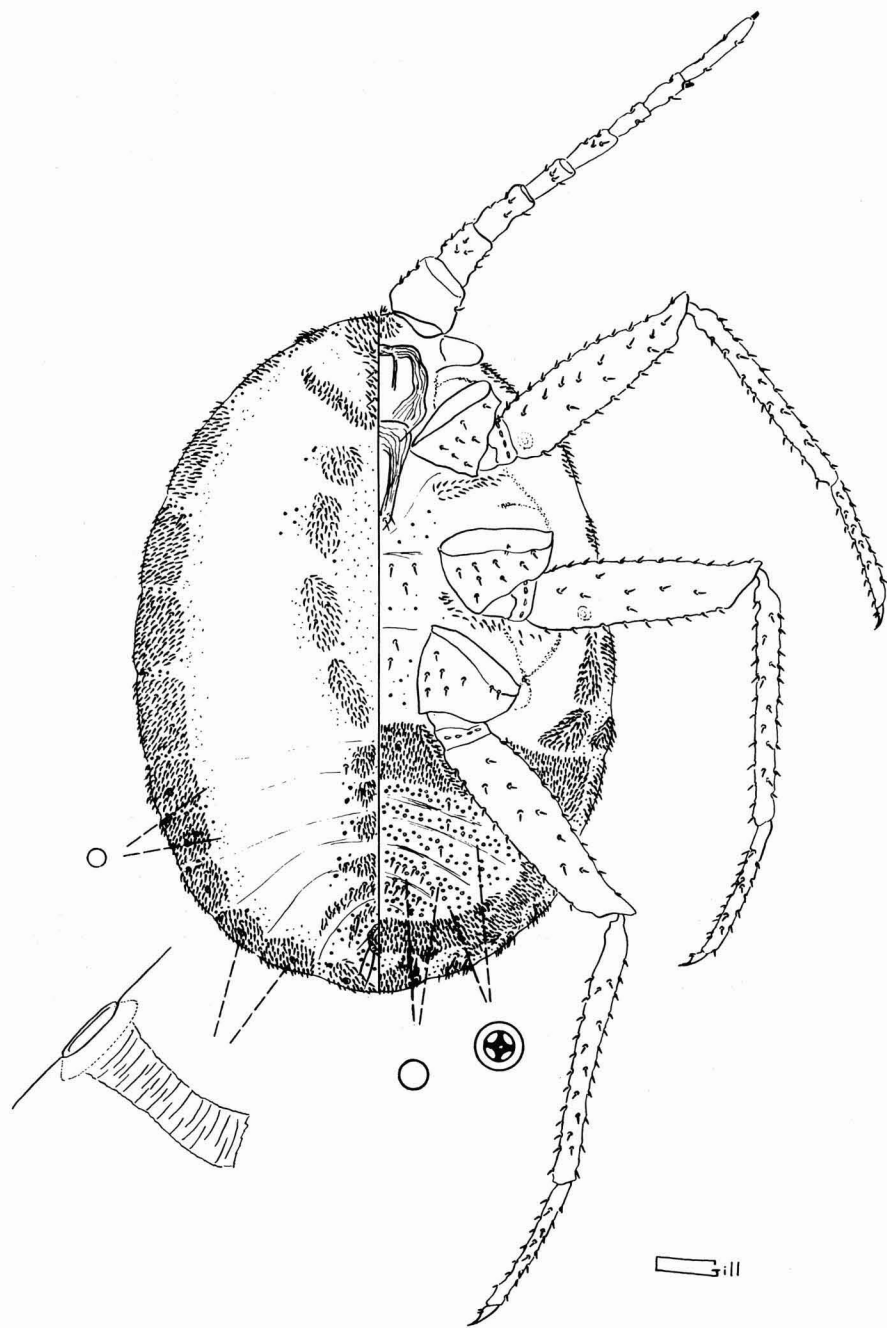


Fig. 45: *Orthezia insignis* Brown.

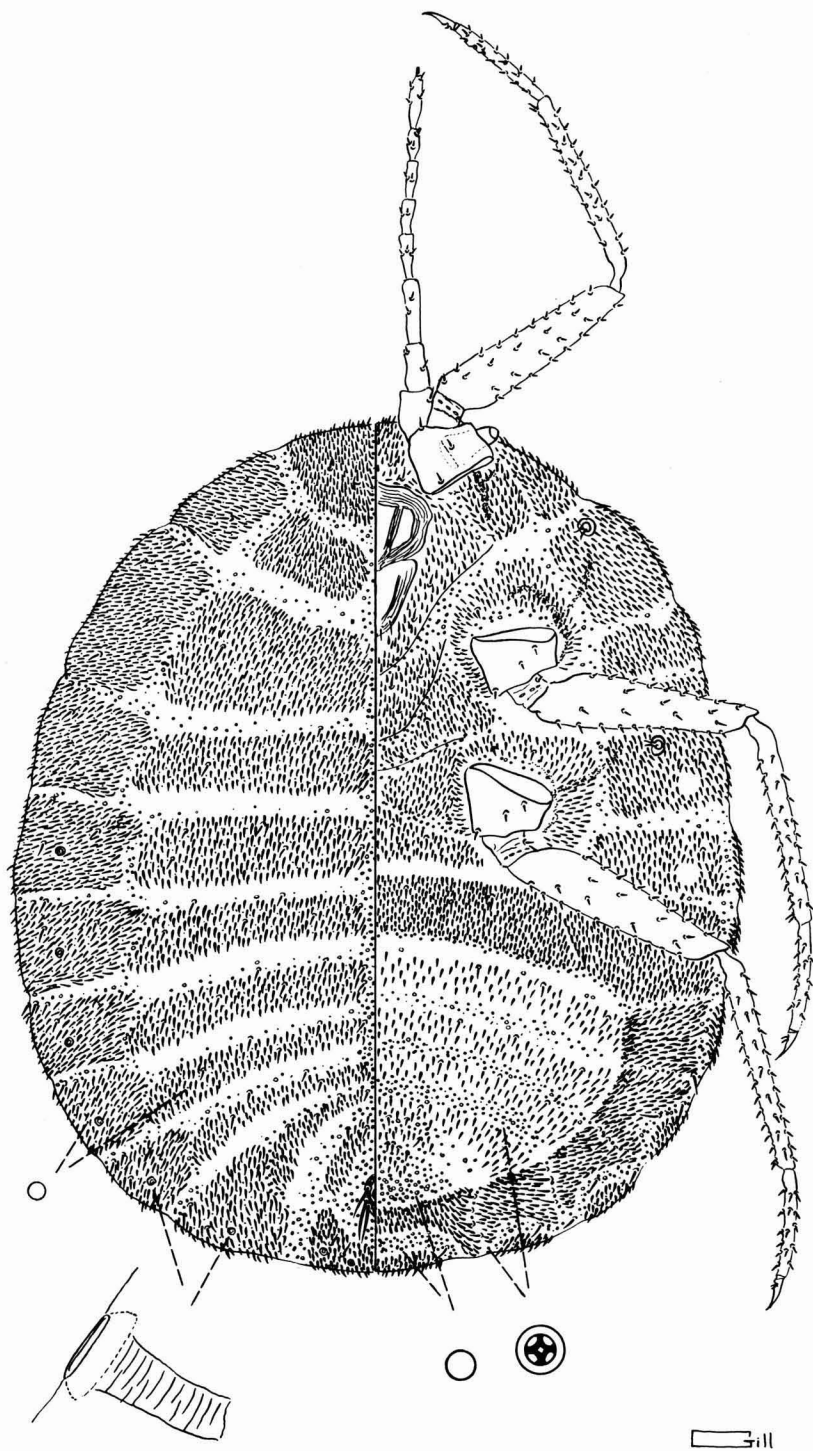


Fig. 46: *Orthezia newcomberi* Morrison.

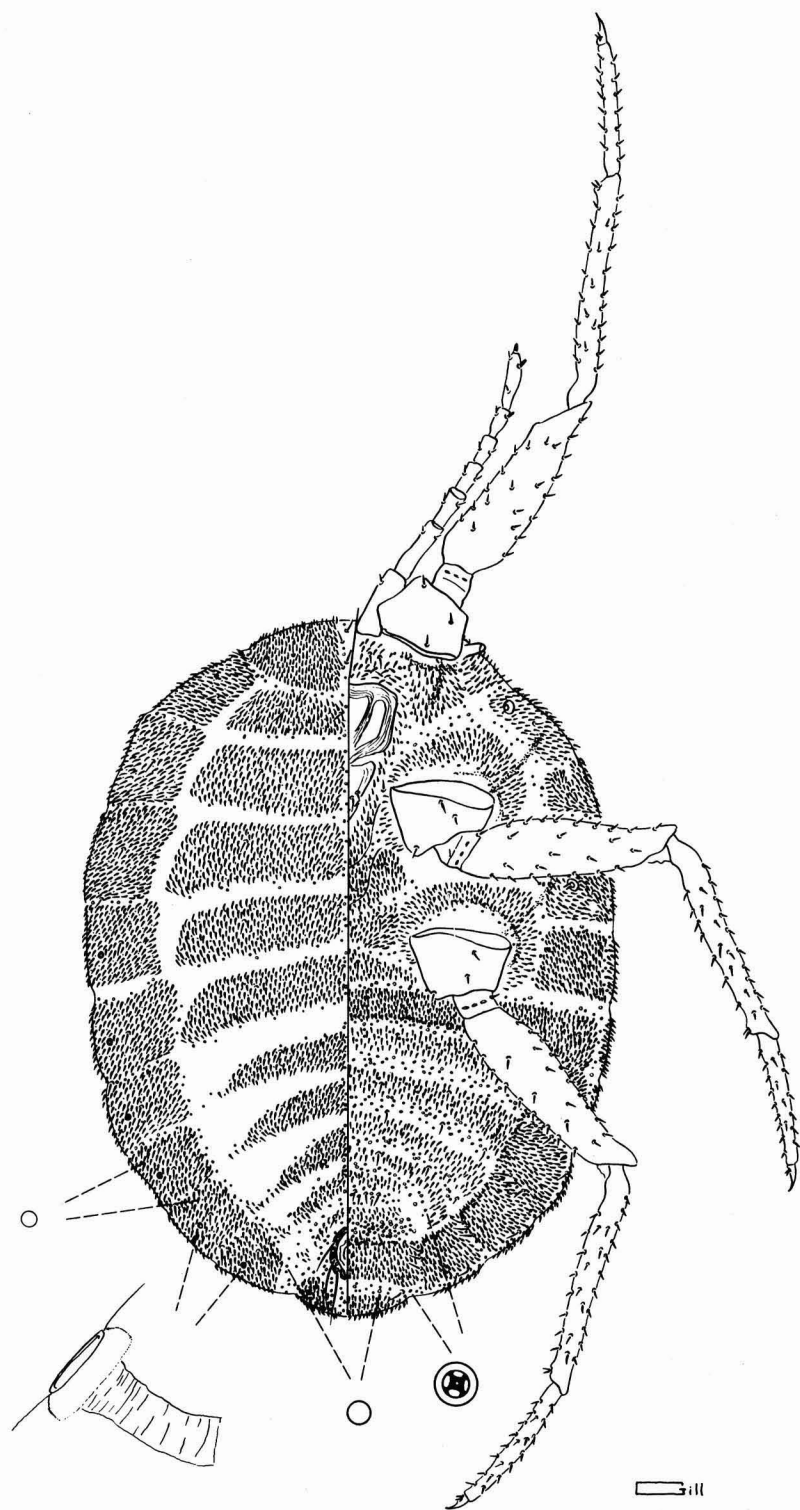


Fig. 47: *Orthezia sarcobati* Morrison.

FAMILY KERRIDAE (TACHARDIIDAE-LACCIFERIIDAE)

lac scales

Color Plates 43-45

This small family contains about 50 species in seven genera. Only one genus, *Tachardiella*, occurs in California. The common family name of "lac scales" refers to the lac or wax produced by the Indian lac scale of Asia, which is used in the production of shellac and varnishes. North American species of lac scales produce a good quality lac, but it is never produced in large enough volume to be of commercial value (see Ferris, 1919c). According to Kearny & Peebles (1969), one species of lac scale occurring on *Coursetia microphylla* in Arizona was used by the Papago Indians to seal jars containing saguaro syrup and is reported to be used by the Mexicans in treating colds and fever. For more information on lac production and on the chemical constituents of lac, see Colton (1943, 1944), Fletcher (1945), Froggatt (1899), Fox (1953), Warth (1956), Lower (1959), Metcalf & Flint (1939) and Stillman (1880). Three species have been recorded from California by Chamberlin (1923 and 1925) and by Ferris (1955). At least one other species has been identified from California by Ferris. However, a number of forms have been collected recently in California which do not seem to match the described species. Even the common species on creosote bush does not match the concepts of *Tachardiella larreae* put forth by Chamberlin. It is this author's opinion that the genus *Tachardiella* should be critically reexamined. Therefore, only a list of described California species and some associated data can be presented with complete accuracy (see comments under the genus *Tachardiella*). Students wishing to key out material to species should refer to the two papers by Chamberlin. A key to the California species, adapted from Chamberlin, is provided here.

Field Characteristics: Length of individuals varies from 2.0 to 4.0 mm depending on the species. Most species known to the author congregate so closely that it is often impossible to tell where one scale cover ends and the next begins. All of the California species cover themselves with a tough, resinous, dark-red, wax cover. Some species produce marginal curls of white wax which are apparently associated with the thoracic spiracles (see Color Plate 44). The common species on creosote bush produces a small raised button of resinous wax on top of the scale cover. Counting these buttons indicates the number of individuals in an aggregation. Males are prevalent in this family. Male puparia are reddish like the female covers and can be found separately but in large numbers near the groups of females.

Similar Species: None.

Hosts: In California, lac scales have been recorded from *Larrea*, *Adenostoma*, *Baccharis*, *Hymenoclea*, *Franseria*, *Cerrillea*, *Bigelovia*, and *Peucephyllum*.

Economic Importance: None.

Distribution: Scales in the genus *Tachardiella* are known only from southern California. They are common in the desert areas of Imperial, Riverside, San Bernardino, and San Diego Counties; they also occur in coastal localities. They have not been collected north of Tecopa, San Bernardino County, in the desert, or north of Perris, Riverside County, in coastal California.

Diagnosis: The glassy red test or cover should readily distinguish the lac scales in the field. Morphologically the brachial plates and the large mid-dorsal spine distinguish the Kerriidae from all other scale families.

References:

- Chamberlin, J. C., 1923: Bull. Entomol. Res. 14:147-212.
 Chamberlin, J. C., 1925: Bull. Entomol. Res. 16:31-41.
 Colton, H.S., 1943: Plateau 16(2):1-12.
 Colton, H.S., 1943: Bul. Mus. No. Ariz. 21:1-24.
 Ferris, G. F., 1919c: J. Econ. Entomol. 12:330-333.
 Ferris, G. F., 1955: Atlas of the Scale Insects of North America. Vol. 7. Stanford Univ. Press, Stanford. 233 pp.
 Fletcher, F. C., 1945: Ward's Natural Sci. Bull. 19(2):30-32.
 Froggatt, W. W., 1899: Agric. Gaz. N. S. W. 10:1159-1163.
 Fox, D. L., 1953: Animal Biochromes and Structural Colors. Cambridge Univ. Press. pp. 205-208.
 Kearney, T. H. and R. H. Peebles, 1969: Arizona Flora. Univ. Calif. Press, Berkeley. 1085 pp.
 Lower, H. F., 1959: Trans. R. Soc. South Aust. 82:175-181.
 Metcalf, O. L. and W. P. Flint, 1939: Destructive and Useful Insects. McGraw-Hill, New York. 981 pp.
 Stillman, J.M., 1880: Amer. Naturalist pp. 782-787.
 Warth, A. H., 1956: The Chemistry and Technology of Waxes, Second. Ed. Reinhold Publ. Co., New York. pp. 76-121.

Genus *Tachardiella* Chamberlin, 1923

Number of world species: 19.

Number of United States species: 7.

Key to the species: Chamberlin, J. C., 1923: Bull. Entomol. Res. 14:147-212.

The systematics of the California species of *Tachardiella* are questionable. There may be a species complex involved with three of the species including, *T. larreae*, *T. pustulata*, and *T. glomerella*. The keys for the separation of the species of *Tachardiella* by Chamberlin (1923) appear to be inadequate for separating the group. Illustrations of the species provided here are taken from well preserved specimens that seem to fit the characteristics set forth for that species by Chamberlin. However, those few characters that Chamberlin used to separate the species are found to be variable within a population, so much so that overlaps between the species limits occur often. There may be a species -host association involved, (i.e. *larreae* with *Larrea*, *glomerella* with *Adenostoma*, and *pustulans* with the *Asteraceae*), but there is no data to substantiate this possibility at the present time. One species, *T. ferrisi*, does appear to be distinct based on the presence of the posterior ventral duct cluster, which is absent from the other three California species, and its field appearance on *Adenostoma* is different than *Adenostoma* specimens that are in the *larreae-glomerella-pustulans* group.

Key to the California species of *Tachardiella*
[adapted from the keys by Chamberlin (1923)]

- 1. Posterior ventral duct clusters always present and well marked *ferrisi*
— Posterior ventral duct clusters absent or else represented by only two or three scattered ducts 2
- 2. Duplex type of marginal duct clusters not evident, without minute scattered ducts around marginal and ventral clusters; canellae much reduced and inconspicuous *larreae*
— Duplex duct clusters plainly evident with minute, scattered tubular ducts around marginal and ventral clusters; canellae prominent 3
- 3. Canellae thin and straggling, without prominent expansion near mouth parts, not tending to connect spiracles; anterior ventral duct cluster divided into two parts *pustulata*
— Canellae definitely well developed, connecting spiracles and extending near mouth parts; anterior ventrals not divided 4
- 4. Median ventral duct clusters very compact and composed of 8 to 14 ducts . . *glomerella*
— Median ventral duct cluster loosely organized and composed of 20 to 25 ducts *baccharidis* form

Tachardiella ferrisi Chamberlin, 1923
Ferris' lac scale

Fig. 48, Color Plate 43

Hosts: Known only from <i>Adenostoma</i> and <i>Eriogonum</i> .	Diagnosis: Readily separated from the other species of California Kerriidae by the presence of the posterior ventral duct clusters, which are absent on the other three species.
Distribution: In California known only at Jacumba, San Diego County. Also known from Baja California, Mexico.	

Tachardiella glomerella (Cockerell), 1905
chamise lac scale

Fig. 49

Synonymy: <i>Tachardia glomerella</i> Cockerell, <i>Tachardiella glomerella</i> form <i>baccharidis</i> Chamberlin.	Distribution: Whittier, California, New Mexico and Texas.
Hosts: Known from chamise (<i>Adenostoma</i>), <i>Baccharis</i> and <i>Gutierrezia</i> .	Diagnosis: Seems to differ from <i>larreae</i> by having more ducts on the body, particularly the overall number of spermatozoid type

ducts both in the marginal duct clusters and randomly distributed on the body. Charac-

ters to separate this species from *T. pustulans* appear to be unreliable.

***Tachardiella larreae* (Comstock), 1882**
creosote bush lac scale

Fig. 50, Color plate 44

Synonymy:

Carteria larreae Comstock, *Tachardia larreae* (Comstock), *Tachardiella larreae* form *californica* Chamberlin.

Hosts: Found on *Larrea* and *Peucephyllum*.

Distribution: San Bernardino, Riverside, and Imperial Counties, California; Arizona.

Diagnosis: Material examined from the type host consistently has fewer of all of the various kinds of ducts than specimens from the *glomerella-pustulans* group. When properly

mounted, specimens readily show the marginal duplex pore groups, contrary to the key by Chamberlin. However, these duct groups have generally fewer of the spermatozoid type ducts and the ducts are more delicate and appear smaller than those of the *glomerella-pustulans* group. The shape of the adult test of specimens from *Larrea* usually have small dorsal dome-like protuberance that specimens from other hosts do not have.

***Tachardiella pustulata* (Cockerell), 1895**
pustular lac scale

Fig. 51, Color Plate 45

Synonymy:

Tachardia pustulata Cockerell.

Hosts: *Bigelovia*, *Baccharis*, and *Chrysothamnus*.

Distribution: Known from Los Angeles, California; Arizona.

Diagnosis: Cannot presently be separated from *T. glomerella*. Further study of the morphology

and biology of this species group needs to be completed before it can be completely understood.

Diagnosis: Readily separated from the other species of California Kerriidae by the presence of the posterior ventral duct clusters, which are absent on the other three species.



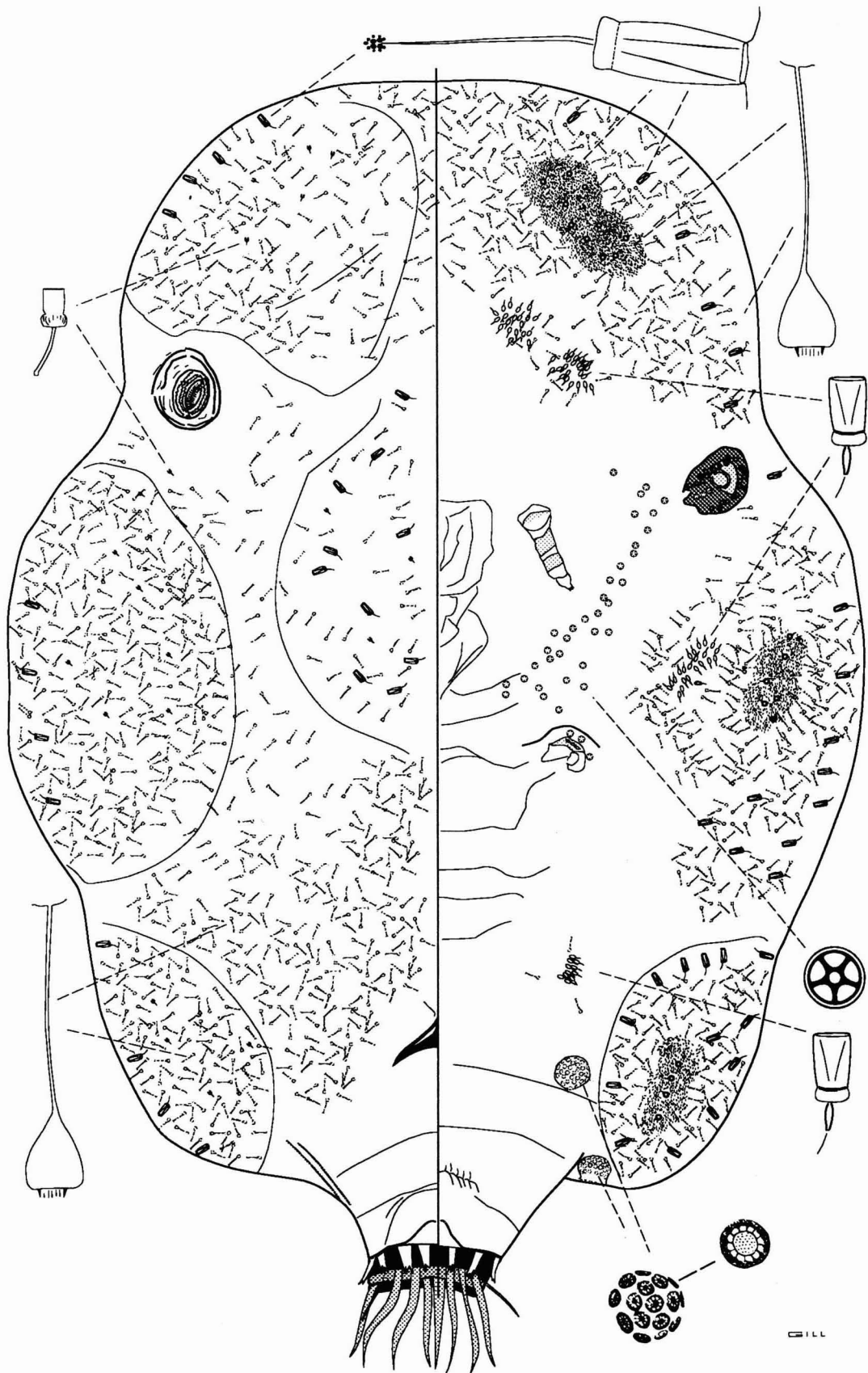


Fig. 48: *Tachardiella ferrisi* Chamberlin.

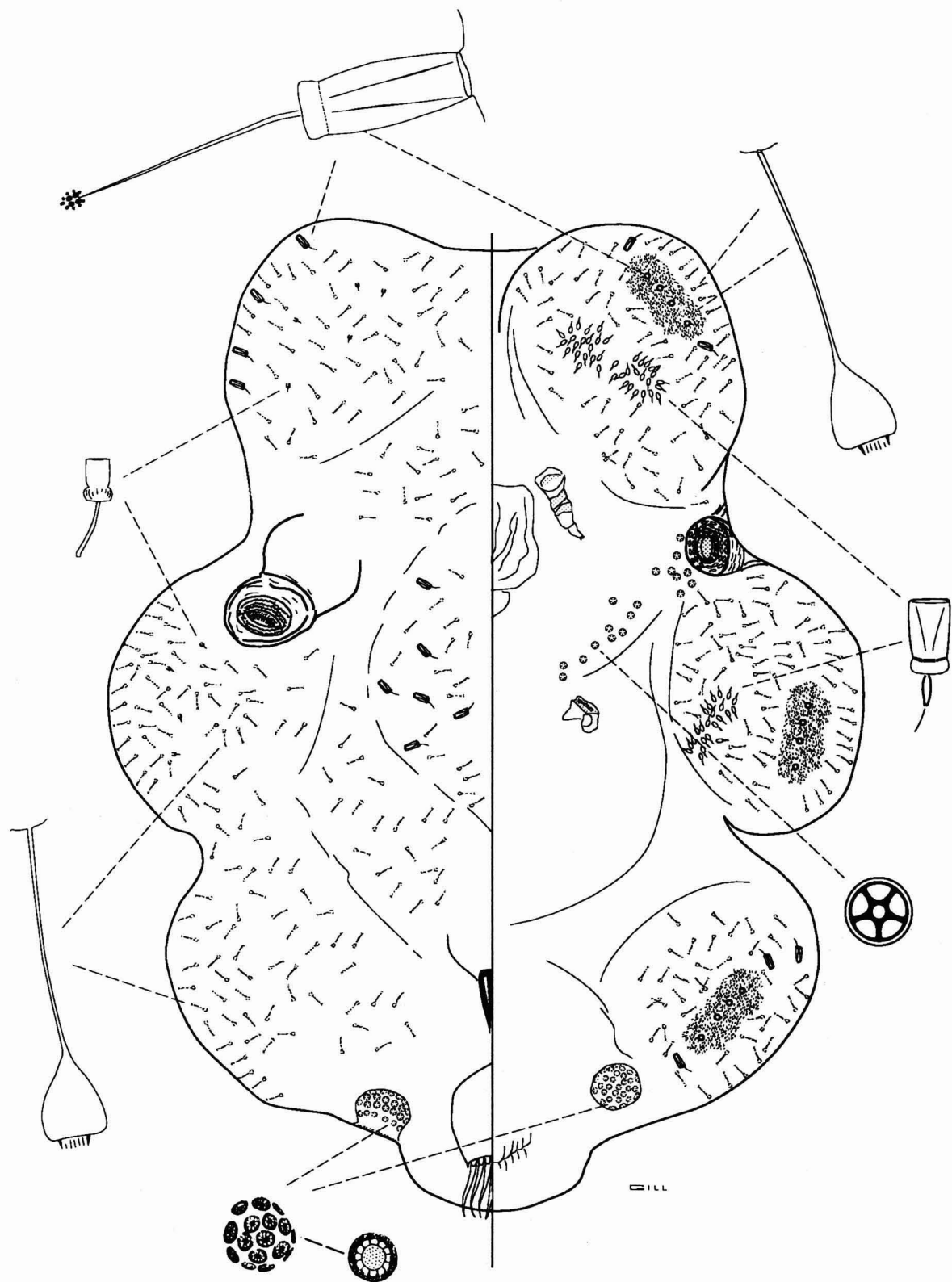
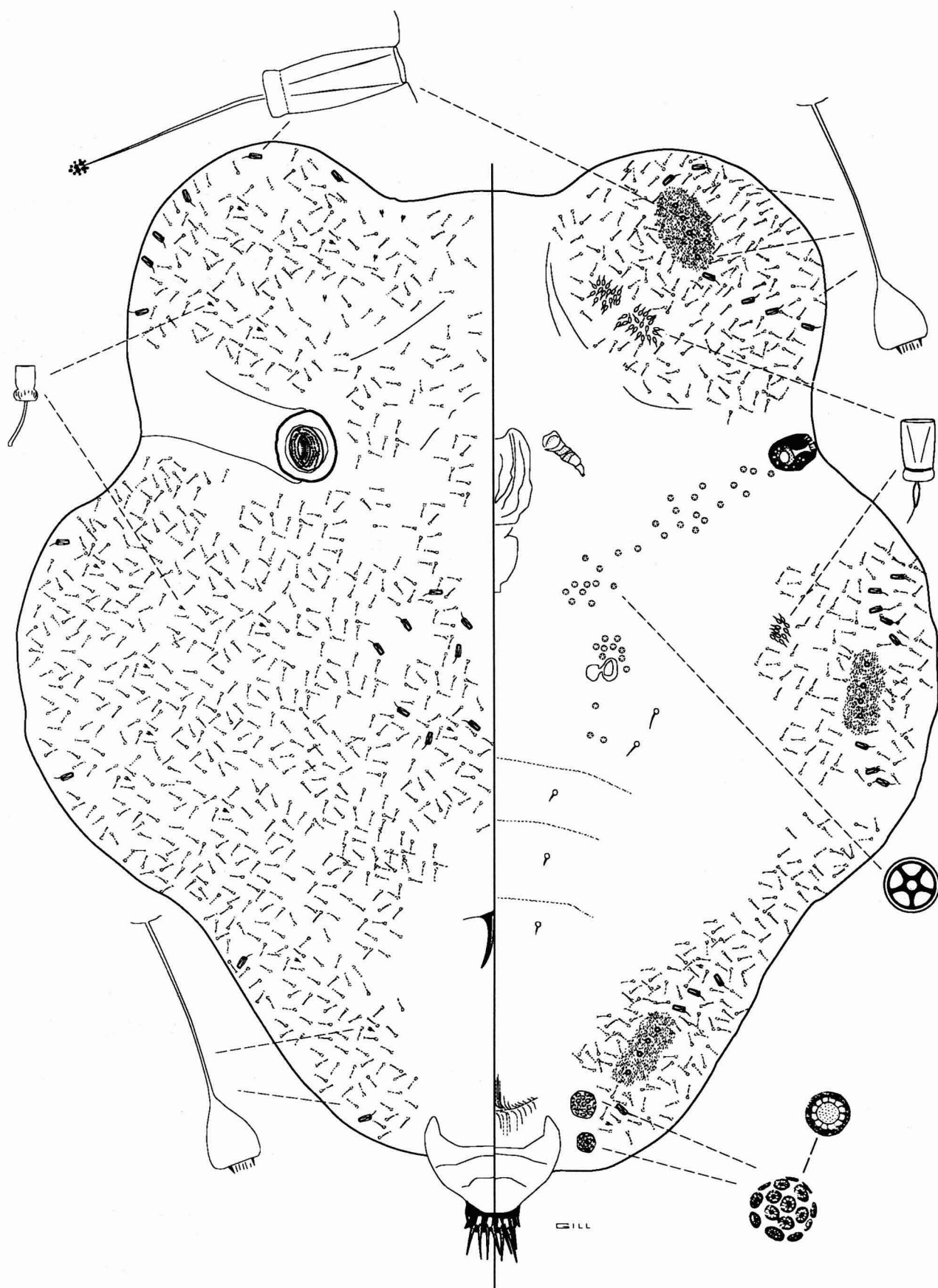


Fig. 50: *Tachardiella larreae* (Comstock).



95

FAMILY ASTEROLECANIIDAE

pit scales

Color Plates 46-56

This family at one time included what are now the families Asterolecaniidae, Lecanodiaspididae, and Cerococcidae. Twenty three genera are known worldwide with the largest number occurring in Australia; five genera are found in North America, four of which occur in California. The genus *Asterolecanium* is the largest genus, with about 160 species. The name *Asterodiaspis* is still used instead of *Asterolecanium* by some European authors, but Russell (1941) maintains that *Asterodiaspis* has no generic validity. Her concept is followed here.

The name pit scale is derived from the fact that a number of species in this family apparently inject some type of chemical into the host while feeding which causes a characteristic "pit-like" growth response. See Color Plate 50.

Field Characteristics: Most members of this family produce a tough wax cover (test) of distinctive shape within which the adult females reside. This scale cover is similar to the cover produced by the armored scales, but with a little practice, the two forms can easily be differentiated in the field. The scale cover or test of the asterolecaniids is usually round, oval, ellipsoidal, oblong, or elongate-oblong, with the posterior edge usually somewhat triangularly produced. No exuviae are present as in the armored scales. The female body fills the whole test cavity, but as egg-laying begins, the body is compressed anteriorly until it is compacted into the front end of the cover. In those species with a transparent test, this characteristic is easily seen by the unaided eye and can be used to get a fair estimate of the age of the population. See Color Plate 50. In addition to the wax cover, many members of the genus *Asterolecanium* and *Bambusaspis* also produce a marginal wax fringe and occasionally dorsal wax fringes, thus resembling whitefly pupae. Pit scales can be differentiated from whiteflies in the field because they are generally larger than whitefly pupae and they are not restricted to the lower leaf surface. Also, in living specimens, if the pit scale specimen is carefully turned over, the four spiracular furrows (furrows leading from the thoracic spiracles to the body margin) will be filled with white wax. These four white radiating lines can readily be seen in pit scales and in soft scales (Coccidae), but never in whiteflies. However, immature or young adult females must be used for this comparison, since the character is obliterated as the female is crowded into the anterior end of the cover. Older females crowded into the anterior part of the covers will distinguish this group immediately.

Similar Species: Whiteflies, armored scales (see Field Characteristics).

Hosts: Polyphagous.

Economic Importance: Some species cause considerable economic injury (see comments under individual species).

Distribution: Worldwide.

Diagnosis: The family is most often characterized by the relatively large 8-shaped (bilocular or geminate) pores, which are also found in the Lecanodiaspididae and Cerococcidae. These 8-shaped pores may be found in other families as well, but they are usually much smaller and are often referred to by other names such as the "minute bilocular pores" found in the Coccidae. The absence of ventral 8-shaped pores and the absence of a sclerotized anal bar or plate distinguishes the pit scales from the Lecanodiaspididae and Cerococcidae, except in the case of *Mycetococcus*, which is otherwise distinct. Russell (1941) gives an account of the biology,

economics and systematics of the genus *Asterolecanium*, as well as a key to the world species known prior to 1941.

References:

Russell, L. M., 1941: U.S. Dep. Agric. Misc. Publ. 424:1-322.

Key to the California Genera of Asterolecaniidae

- 1. Adult female with the apical lobes and the posterior extremity of the abdomen strongly sclerotic (Fig. 60) *Mycetococcus*
— Adult female at times with the anal lobes sclerotic but this never involving entire the posterior extremity of the body 2
- 2. Adult female without tubular ducts, only 8-shaped pores *Pollinia*
— Adult female always with some tubular ducts (Figs. 52-59) 3
- 3. Occurring only on bamboo (*Bambusa*); with a pair of elongated dorsal tubes at the posterior end of the abdomen *Bambusaspis*
— Occurring on hosts other than bamboo; lacking posterior dorsal abdominal tubes *Asterolecanium*

Key to the California Species of *Asterolecanium* and *Bambusaspis*

- 1. Anal ring and margin of anal opening without setae: restricted to oaks (*Quercus*) . . . 2
— Anal ring with 6 setae, on hosts other than *Quercus* 4
- 2. Multilocular pores in 3 rows, usually totalling 6-8, but very rarely up to 13; apical setae 28-32µ long *A. minus*
— Multilocular pores in more than 3 rows and totaling at least 23; apical setae 32-64µ long . . 3
- 3. Usually with 23-33 multilocular pores, but rarely with as many as 38; mounted specimens averaging 1.25mm. in diameter; apical setae averaging 34µ long *A. quercicola*
— Usually with 50-62 multilocular pores, but rarely with as few as 40 and occasionally with as many as 72; mounted specimens averaging 1.95mm. long and 1.5 wide; apical setae averaging 38µ long *A. variolosum*
- 4. Marginal 8-shaped pores in a double or triple row 5
— Marginal 8-shaped pores in a single row 7
- 5. Apex of abdomen with 5 pairs of setae; primarily found on plants in the Agavaceae *A. grandiculum*
— Apex of abdomen with 6 pairs of setae; primarily found on other hosts besides the Agavaceae 6
- 6. Abdominal multilocular pores numbering more than 55, usually with 10 loculae, arranged in 4 to 8 partial to complete rows; often found on *Pittosporum*, *Penstemon*, *Ceanothus* and many other hosts *A. arabis*

- Abdominal multilocular pores numbering less than 55, usually with 9 loculae, arranged in 3 to 4 partial to complete rows; primarily found on plants in the Euphorbiaceae *A. stentae*
- 7. Dorsal tubes present; found only on bamboo and its relatives *B. bambusae*
- Dorsal tubes absent, found only on plants in the Agavaceae *A. agavis*

THE ASTEROLECANIIDAE OF CALIFORNIA

Genus *Asterolecanium* Targioni-Tozzetti, 1868

Number of world species: About 120.
Number of United States species: 10.
Key to the world species: Russell (1941).

Asterolecanium agavis Russell, 1941
agave pit scale

Fig. 52, Color Plate 46

Field Characteristics: Adult females 1.5 to 2.0 mm long. Adult female scale cover semi-transparent; pale green; nearly the same color as the host leaf; with a short marginal wax fringe. Scales occur in a shallow depression in the leaf surface.

Biology: Unknown, but probably has one yearly generation.

Similar Species: *Asterolecanium grandiculum* is nearly identical in the field.

Hosts: Known only from Joshua tree (*Yucca brevifolia*) in California. Occurs on *Agave* and *Yucca* in other areas.

Economic Importance: Causes pitting and discoloration of host leaves. Otherwise rare and non-economic.

Distribution: Boron, Kern County; Arizona, Texas.

Diagnosis: Differs from *A. grandiculum*, the only other California species on *Agave* and *Yucca*, by possessing a single row of marginal 8-shaped pores.

Asterolecanium arabidis (Signoret), 1876
pittosporum pit scale

Fig. 53, Color Plates 47-49

Other Common Names: Pit-making pittosporum scale, ivy pit scale.

Synonymy: *Planchonia arabidis* Signoret, *Planchonia hederæ* Lichtenstein, *Planchonia valloti* Lichtenstein, *Asterolecanium massalongianum* Targioni-Tozzetti, *Pollinia thesii* Douglas.

Field Characteristics: Forms a tan wax cover or test up to 5.0 mm long; with a wax fringe around the margin and along the dorsal mid-line. These fringes, particularly the dorsal ones, are easily rubbed off. Presence of the scale is usually noticeable because of the stunting, distortion, and discoloration of the termi-

SCALE INSECTS OF CALIFORNIA

nal shoots of the host. Apparently a toxin is injected into the plant which produces a "pit-forming" response. The scales usually congregate on the growing tips and the overall effect is a severe distortion of tissue that often obliterates the "pits" formed by individual scales.

Biology: Has one yearly generation. In Italy, first instars hatch in April and May. Maturity is reached and egg laying begins in August. Overwintering takes place in the egg stage inside the parental female tests. For more information see Tranfaglia (1974).

Similar Species: Some of the scales in the Lecanodiaspididae have the same color wax test and are about the same size.

Hosts: Prefers *Pittosporum tobira* and *Ceanothus*, but has a long host list. For more information, see Essig (1945) and Komosinska & Podsiadlo (1967).

Economic Importance: This scale, probably native to Europe, causes serious distortion and death of the growing tips of ornamental hosts, particularly *Pittosporum*. Affected plants are severely weakened and unsightly. In central Europe, causes deformations on leaves and stems of English Ivy (*Hedera helix*) (Kosztarab, pers. comm.). The scale is regulated by quarantine laws in California, and nursery stock is required to be free of the insect. In an unusual instance in the State of Washington, this species caused up to a 50 percent loss in a commercial sugar beet field

FAMILY ASTEROLECANIIDAE

(Landis, 1968). In the Sacramento area, the scale is attacked by natural enemies which are affecting a considerable amount of control. For more information on biology, see Tranfaglia (1974).

Distribution: Found in most of the counties around San Francisco Bay. Also found in the San Joaquin Valley from Sacramento south to Kern County. Known from several western states, the northeastern United States, and most of Europe.

Diagnosis: The three marginal rows of 8-shaped pores distinguish this scale from all other California species. However, the similar appearing and apparently closely related south African species *A. stentae* Brain has been found infesting Euphorbiaceae in nurseries in San Diego County. This species also has 6 anal ring setae and a double or triple row of marginal 8-shaped pores, but differs from *arabidis* in having less than 5 rows of ventral abdominal multilocular pores with a total of 14-55 pores. *A. arabidis* has 5-8 rows of multiloculars totalling 55-180 pores.

Essig, E. O., 1945: Calif. Dep. Agric. Mon. Bull. 34(3):134-136.

Komosinska, H. and E. Podsiadlo, 1967: Bull. Acad. Pol. Sci. Ser. Biol. 25(11):683-686.

Landis, B. J., 1968: J. Econ. Entomol. 61(3):871-873.

Tranfaglia, A., 1974: Boll. Lab. Entomol. Agrar., Portici 31:54-60.

Asterolecanium grandiculum Russell, 1941 large pit scale

Fig. 54

Other Common Names:

Yucca pit scale.

Field Characteristics: Adult females 1.75 to 2.50 mm long. Adult female scale covers semi-transparent; yellow to greenish; covered completely with curled transparent wax filaments, longer on the midline and around the margin.

Biology: Unknown.

Similar Species: Other species of *Asterolecanium*, but the restricted host list and range in California should distinguish this species from all others except *A. agavis*.

Hosts: Prefers *Agave* and *Yucca*. Also known from Boojum tree (*Fouquieria columnaris*) and myrtle (*Myrtus communis*).

Economic Importance: None.

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Distribution: Imperial and San Diego Counties; Arizona, Mexico. Probably native to Mexico.

Diagnosis: The relatively large number and large size of the dorsal 8-shaped pores, along

FAMILY ASTEROLECANIIDAE

with the host and range restrictions, distinguish this species from all others except *A. agavis*. It differs from that species by having 2 irregular rows of marginal 8-shaped pores.

Asterolecanium minus Lindinger, 1912 least pit scale

Fig. 55, Color Plate 50

Synonymy:

Asterodiaspis minor Lindinger.

Field Characteristics: Adult females 1.0 to 1.5 mm long; green to yellow or brown, depending on age. Nearly always found within a raised pit on the smaller twigs and branches.

Biology: Parthenogenetic; univoltine. According to Okiwelu (1977), crawlers are produced from April through August, with the majority produced in May. For more information on biology, see Boratynski (1961).

Similar Species: There are two other species of oak pit scales in California, *Asterolecanium quercicola* and *A. variolosum*. Pit scales on oak should not be confused with any other scale insects.

Hosts: Prefers white oaks such as valley oak (*Quercus lobata*) and blue oak (*Q. douglasii*); also found on coast live oak (*Q. agrifolia*) and California black oak (*Q. kelloggii*).

Economic Importance: A serious pest of oaks in California. Causes severe debilitation and sometimes death of the trees. It has been associated with the twig blight fungus *Diplodia quercina*, and according to Hecht-Poinar et al. (1989), there is a positive correlation between disease severity and the level of the scale infestation. For more information on the biology and economics of *Asterolecanium minus* and the other oak pit scales, see Pritchard & Beer (1950a and 1950b), Boratynski (1961), Koehler & Tamaki (1963), Koehler et al. (1965), Okiwelu (1977), and Parr (1940). Parasites of this scale have not been found in California.

Distribution: Throughout California where host oaks occur. The species is native to the

old world, but has been introduced to many areas of the United States.

Diagnosis: Easily recognized because it has less than 10 multilocular pores on the abdominal venter. Podsiadlo (1974a) considers *minus* to be a synonym of *quercicola*, because the number of multilocular pores have been shown to overlap in some European locations. However, this has not been noted in the U.S. and it appears that the two species are in fact distinct; they will be treated as such in this work. Also, Boratynski (1961) finds differences in the first instar nymphs of *minus* and *quercicola*.

Boratynski, K., 1961: Proc. R. Entomol. Soc. London, Ser. B. 30:4-14.

Brown, L. R. and C. O. Eads, 1965: Calif. Agric. Exp. Stn. Bull. 810:1-105.

Hecht-Poinar, E. I., L. R. Costello and J. R. Parmeter Jr., 1989: Calif. Agric. 43(1): 15-16.

Koehler, C. S. and G. Tamaki, 1964: Ann. Entomol. Soc. Am. 57:146-150.

Koehler, C. S., L. R. Brown, C. O. Eads, and M. D. Davis, 1965: Univ. Calif. Agric. Ext. Serv. O.S.A. Ser. Bull. 167.

Okiwelu, S. N., 1977: Ann. Entomol. Soc. Am. 70(4):615-621.

Parr, T., 1940: Yale Univ. School. For. Bull. 46:1-49.

Podsiadlo, E., 1974a: Acta Zool. Cracov. 19(20):489-530.

Pritchard, A. E. and R. E. Beer, 1950a: J. Econ. Entomol. 43(4):494-497.

Pritchard, A. E. and R. E. Beer, 1950b: Calif. Agric. 4(4):9, 14.

Asterolecanium quercicola (Bouché), 1851
drab pit scale

Fig. 56

Synonymy:

Lecanium quercicola Bouché, *Asterococcus quercicola* (Bouché), *Asterodiaspis minor* (Bouché).

Field Characteristics: Field appearance essentially the same as *Asterolecanium minus*. Adults 1.25 to 1.75 mm long.

Biology: Like *A. minus*, it is parthenogenetic and univoltine. See Boratynski (1961).

Similar Species: *Asterolecanium minus* and *A. variolosum*.

Hosts: Oaks in the white oak group. See *A. minus*.

Economic Importance: Can be detrimental to oaks. Far less common in California than *A. minus*. While there are no parasites known

from this species in California, Richard Penrose, formerly of the Oregon Department of Agriculture, states that some parasitization occurs in that state.

Distribution: Throughout California.

Diagnosis: Distinguished by the 20 to 35 multilocular pores on the venter. Podsiadlo (1974a) considers *minus* to be a synonym of this species (see comments under *minus*).

Boratynski, K., 1961: Proc. R. Entomol. Soc. London, Ser. B. 30:4-14.

Podsiadlo, E., 1974a: Acta Zool. Cracov. 19(20):489-530.

Asterolecanium stentae Brain, 1920
euphorbia pit scale

Fig. 57, Color Plate 51

Field Characteristics: Field appearance essentially the same as *Asterolecanium arabis*. Adults 1.50 to 2.25 mm long.

Biology: Unknown.

Similar Species: *Asterolecanium arabis*.

Hosts: Plants in the families Euphorbiaceae and Asclepiadaceae.

Economic Importance: Unknown. It does cause pitting in the host and therefore has a potential to be a problem on nursery stock and specimen plants.

Distribution: Has been found twice in nurseries in San Diego County. It is not known if any of the infested plants have been sold to gardeners or if has become established outside the nursery situation. Described from southern Africa, where it is probably native.

Diagnosis: Nearly identical in appearance to *A. arabis*. It differs in having fewer ventral abdominal multilocular pores, fewer loculae in the multilocular pores, but more numerous dorsal 8-shaped pores.

Asterolecanium variolosum (Ratzeburg), 1870
golden pit scale

Fig. 58, Color Plate 52

Other Common Names:

Golden oak scale, pustular scale, pitmaking oak scale.

Synonymy:

Coccus variolosum Ratzeburg, *Asterodiaspis variolosum* (Ratzeburg).

SCALE INSECTS OF CALIFORNIA

Field Characteristics: Adult females 1.75 to 2.25 mm long. Otherwise the color and other characteristics are the same as for the previous two species.

Biology: For information on biology, see Parr (1940).

Similar Species: *Asterolecanium minus*, *A. quercicola*.

Hosts: Restricted to English oak (*Q. robur*) and California black oak (*Q. kelloggii*).

Economic Importance: None. For information on natural enemies, see Gourlay (1935) and Bartlett (1978).

Distribution: Very rare in California. Known only from the first California record at Stockton in 1913 and, according to Pritchard & Beer (1950a), a collection in Marin County.

Diagnosis: Host restriction and the large number of ventral multilocular pores (50-65) distinguish this species. For more informa-

FAMILY ASTEROLECANIIDAE

tion see Podsiadlo (1972 & 1974b). Recent work by Podsiadlo (1990) suggests that *A. minus*, *A. quercus* and *A. variolosum* are all polymorphic forms of the same species.

Bartlett, B. R., 1978: U.S. Dep. Agric., Agric. Handb. 480:1-545.

Gourlay, E. S., 1935: N. Z. J. Sci. Tech. 16(4):216-235.

Parr, T., 1940: Yale Univ. School For. Bull. 46:1-49.

Podsiadlo, E., 1972: Acta. Zool. Cracov. 17(17):389-407.

Podsiadlo, E., 1974b: Ann. Zool. 32(7):75-102.

Podsiadlo, E., 1990: Ann. Zool. 43(18):363-371.

Pritchard, A. E. and R. E. Beer, 1950a: J. Econ. Entomol. 43(4):494-497.

Genus *Bambusaspis* Cockerell, 1902

Number of world species: About 40.

Number of U.S. species: Probably 4.

Key to world species: Russell (1941) [as *Asterolecanium*, the key starts at couplet 102].

Bambusaspis bambusae (Boisduval), 1869 bamboo pit scale

Fig. 59, Color Plate 53

Synonymy:

Chermes bambusae Boisduval.

Field Characteristics: Adult females 1.5 to 3.5 mm long; oval; wax cover or test glass-like, transparent yellow or green; usually takes on color of host. Immatures the same color as adults. Later instars and adults have a marginal fringe of transparent wax of about the same color as the cover, thus closely resembling whitefly pupae. Normally found on stems, but also found on both leaf surfaces.

Similar Species: At least 27 species of *Asterolecanium* similar to this one occur on bamboo or its relatives in other parts of the

world. The species superficially resembles whiteflies, but whiteflies as a rule are not found on the upper leaf surfaces or stems of the host.

Biology: Parthenogenetic. All stages can be found on the plant at one time. The number of yearly generations has not been determined.

Hosts: Favors bamboo; in California usually found on giant bamboo (*Phyllostachys*). Also known from *Arundinaria*, *Dendrocalamus*, *Gigantochloa*, and *Oxytenanthera*.

Economic Importance: None in California. Probably native to the Orient. Not common. Does not appear to have much effect on the host.

SCALE INSECTS OF CALIFORNIA

Distribution: Usually found in southern California.

Diagnosis: Should not be confused with any other California *Asterolecanium*. However, there are almost 30 species found on bamboo or closely related plant genera, and the key

FAMILY ASTEROLECANIIDAE

provided by Russell (1941) should be used when making identifications.

Russell, L. M., 1941: U.S. Dep. Agric. Misc. Publ. 424:1-322.

Genus *Mycetococcus* Ferris, 1918

Number of world species: 2.

Key to world species: Ferris (1955).

Mycetococcus ehrhorni (Cockerell), 1895 Ehrhorn's oak scale

Fig. 60, Color Plate 54

Other Common Names:

mycelium scale.

Synonymy:

Cerococcus ehrhorni Cockerell.

Field Characteristics: This unusual species has apparently developed a symbiotic relationship with the fungus *Septobasidium canescens* (Patterson, 1901 and Ferris, 1955), and always seems to be found in association with it. The fungus protects the scales from natural enemies and the elements, and the fungus derives nourishment from the honeydew produced by the scale. Adult females about 1.0 mm long. All stages bright red; surrounded by a thin white scale cover; and found on bark under the white or greyish mycelial mat. Heavy infestations of scale and fungus give the trees a whitewashed appearance.

Similar Species: *Mycetococcus corticis* (Townsend & Cockerell) from Nogales, Arizona and Veracruz, Mexico.

Hosts: Restricted to evergreen oaks such as *Quercus agrifolia*, *Q. chrysolepis*, and *Lithocarpus densiflora*.

Economic Importance: Was considered the most common scale insect pest of oaks in southern California by Emory Myers of Los

Angeles County, although oak pit scales are probably more common now. Herbert (1936) considered this scale to be quite serious on oak. The above economic information summarized from Herbert (1936) and Brown & Eads (1965a).

Distribution: Most frequently found in southern California; occurs as far north as San Francisco and probably occurs farther north along the coast. Also collected from Santa Cruz Island.

Diagnosis: The 8-shaped pores and the large, acute, heavily sclerotized anal lobes will immediately distinguish this species. *Mycetococcus corticis*, found on oak in Mexico, has much less acutely pointed anal lobes with many long spine-like setae.

Ferris, G. F., 1955: Atlas of the Scale Insects of North America, Vol. 7. Stanford Univ. Press, Stanford. 233 pp.

Brown, L. R. and C. O. Eads, 1965a: Calif. Agric. Exp. Stn. Bull. 810:1-105.

Herbert, F. B., 1936: Proc. West. Shade Tree Conf. 3:32-44.

Patterson, R. W., 1901: Proc. Calif. Acad. Sci. 3rd Ser. Zool. 2:388-398.

Genus *Pollinia* Targioni-Tozzetti, 1868

Number of North American species: 1, monotypic.

***Pollinia pollini* (Costa), 1857**
olive pollinia scale

Fig. 61, Color Plates 55-56

Synonymy:

Coccus pollini Costa, *Pollinia costae* Targioni-Tozzetti.

Field Characteristics: Adult females yellow; completely enclosed within a tough, white, waxy, irregular covering (test) which measures about 2.0 mm in length. Scale tests normally white, but often covered with honeydew and sooty mold produced by nearby black scale colonies. Sooty mold and dust tend to stick to the tests and, in some situations, completely hide the insects. Male scales present; cocoons similar in construction to those of the female tests, but smaller, oblong, and cream yellow. All stages occur on twigs, small branches, and particularly twig axils.

Biology: According to Leonardi (1920), Armitage & McKenzie (1952) and Alexandrakis (1980) there are two generations per year.

Similar Species: None.

Hosts: Restricted to olive (*Olea europaea*).

Economic Importance: Causes defoliation and stunting of olive in the Mediterranean region. Sporadic outbreaks have been reported recently in Italy and Greece (Swirski, 1985), but on the island of Crete, at least, it occurs primarily on sick trees growing in poor soil (Stavrakis et al., 1979). Does not seem to cause much injury in California, but the infested trees are neglected roadside specimens and no conclusions can be drawn regarding overall effects or yield losses. Possible effect on commercial olives in California is unknown.

Distribution: Has been found and eradicated from several areas in the state (Armitage & McKenzie, 1952). Infestations at Jamul, San Diego County, were not eradicated, but the present status of the infestation is unknown. The only known infestation of this scale in California is in the Cloverdale-Asti-Geyserville area of Sonoma County. Native to the Mediterranean region. For more information on this scale in the Mediterranean region see Alexandrakis (1980 and 1984).

Diagnosis: The illustration provided, along with the host restriction and field characteristics, distinguish this species.

Alexandrakis, V., 1980: Ann. Soc. Entomol. Fr. (NS) 16(1):9-17.

Alexandrakis, V., 1984: In: Proc. CEC/FAO/IOBC International Joint Meeting: Integrated Pest Control in Olive Groves. 512 pp.

Armitage, H. M. and H. L. McKenzie, 1952: Calif. Dep. Agric. Bull. 41:115-121.

Leonardi, G., 1920: Monografia delle Cocciniglie Italiane. Portici, Della Torre. 555 pp.

Stavrakis, H.G., L.C. Argyriou and C. Yamvrias, 1979: IOBC/WPRS on Integrated Control in Agriculture and Forestry, Vienna, pp. 574-577.

Swirski, E. 1985: Atti XIV Congr. Naz. Ital. Ent., Palermo, Erice, Bagheria. pp. 781-799.

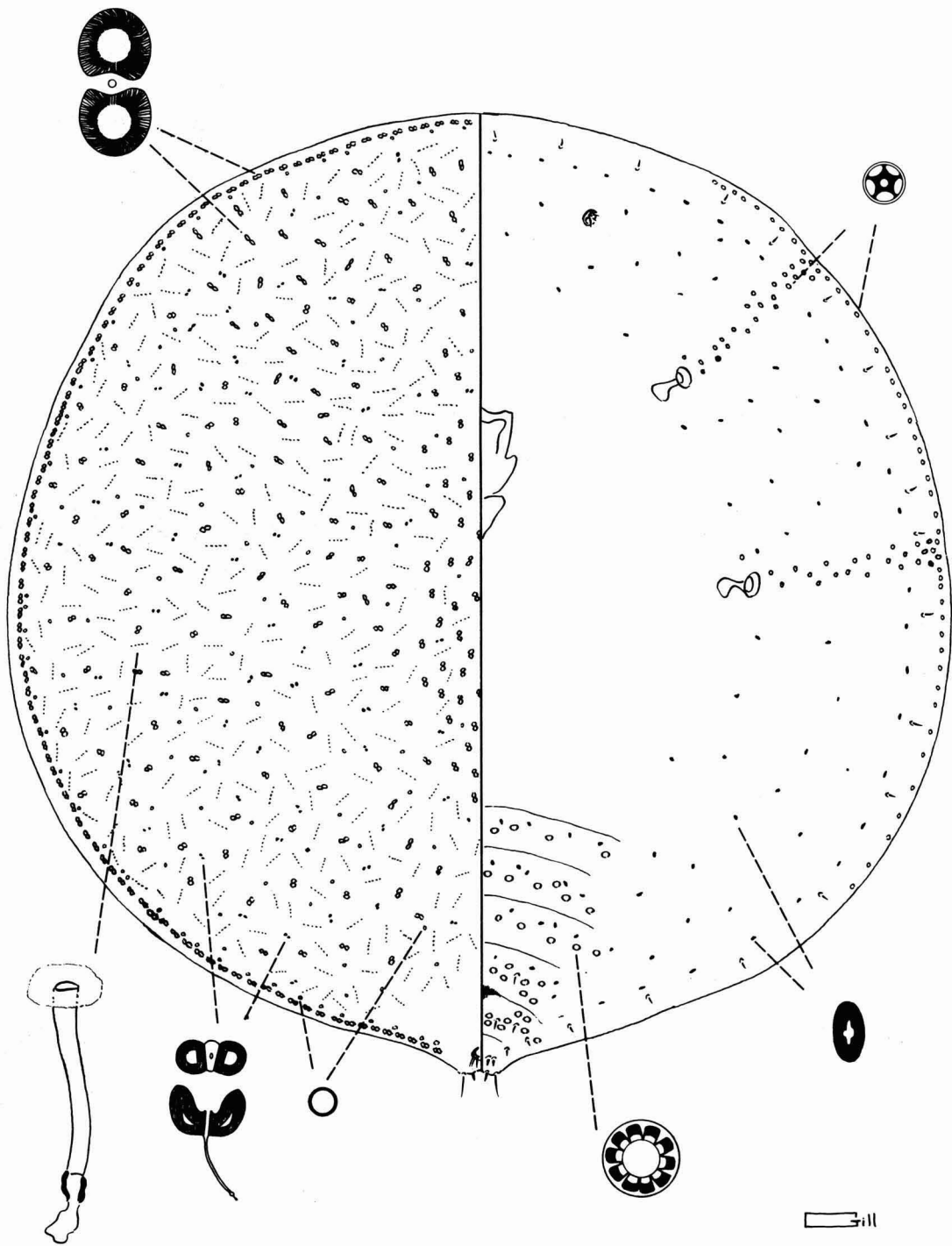


Fig. 52: *Asterolecanium agavis* Russell.

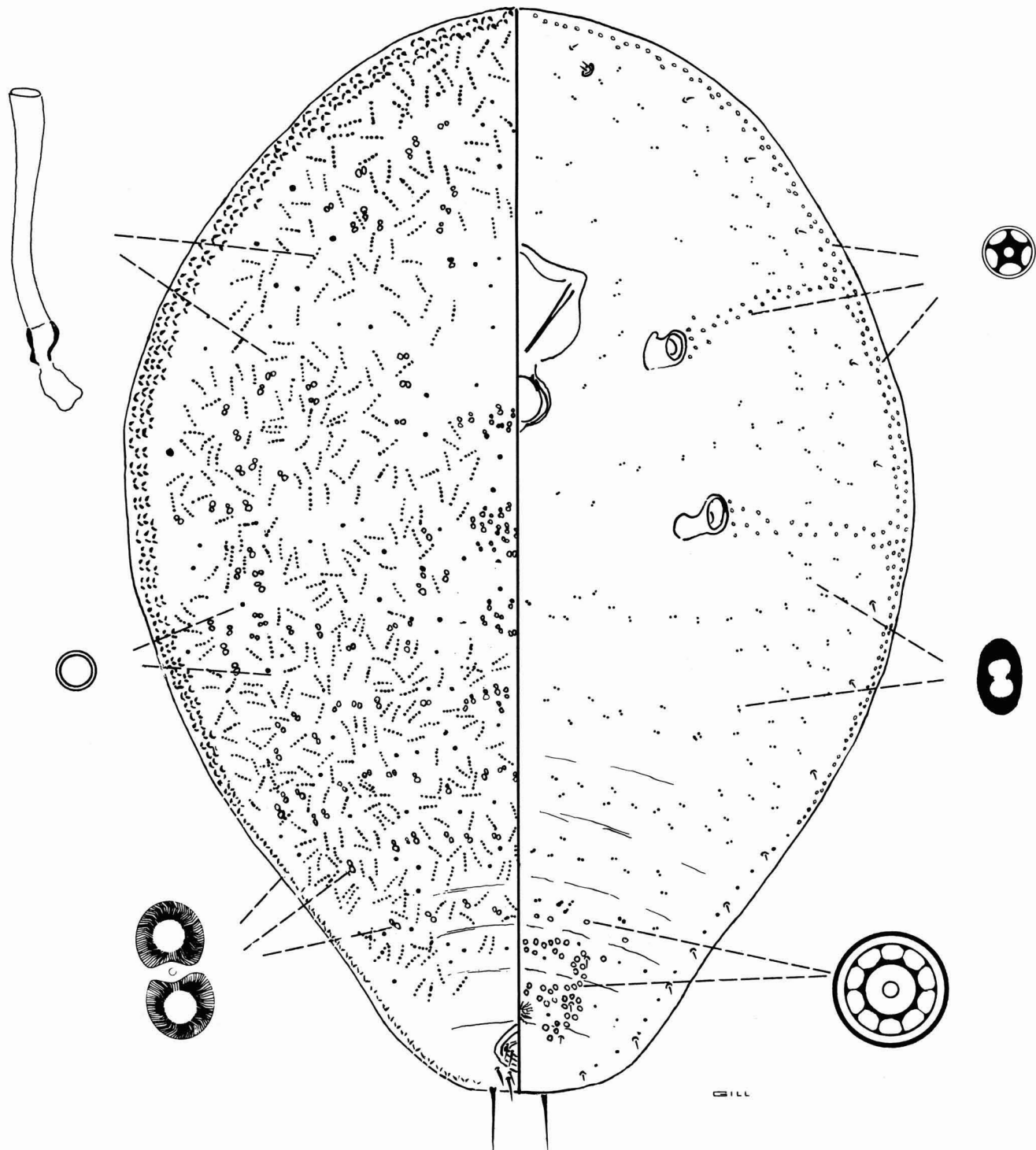


Fig. 53: *Asterolecanium arabidis* (Signoret).

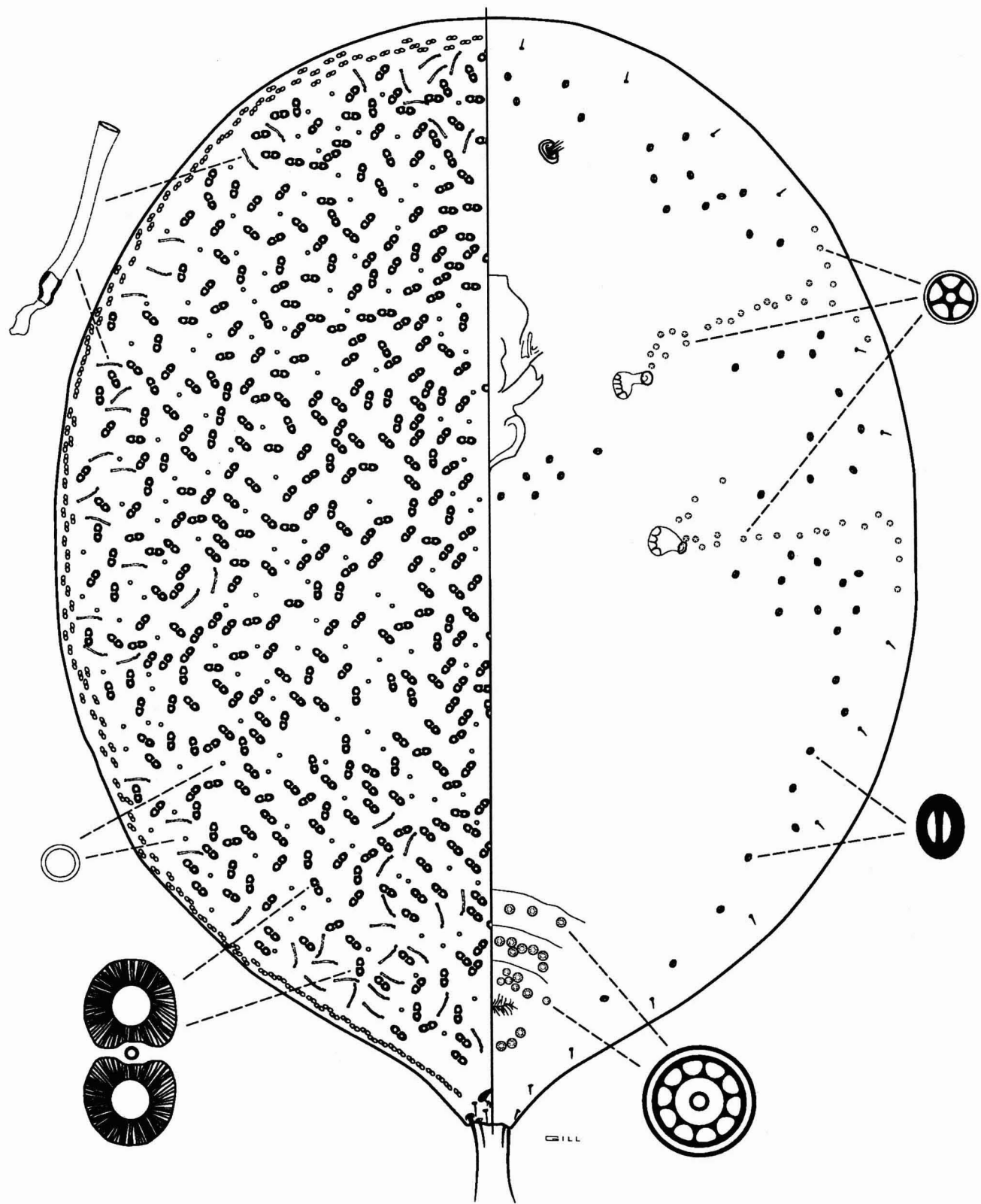


Fig. 54: *Asterolecanium grandiculum* Russell.

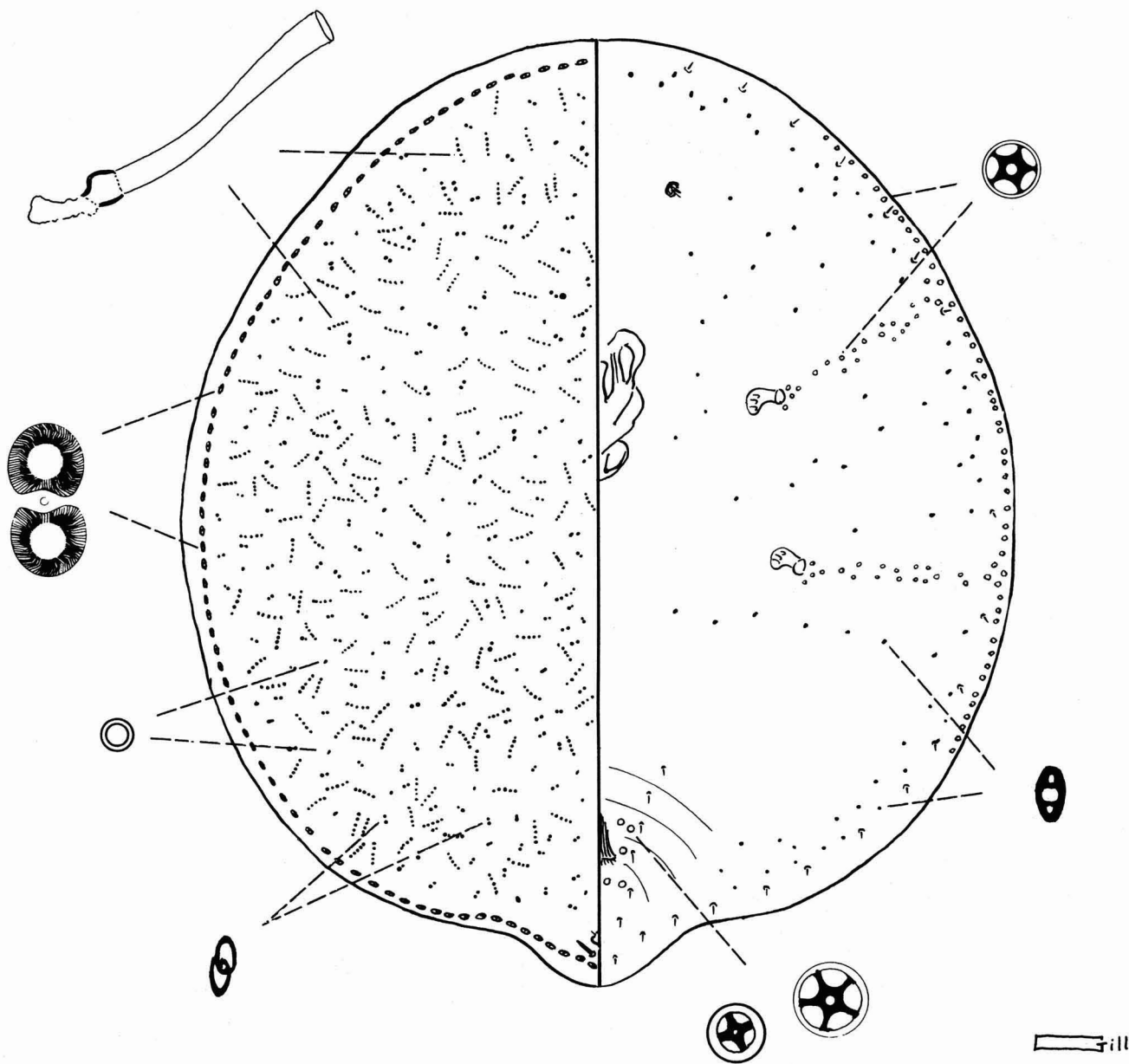


Fig. 55: *Asterolecanium minus* Lindinger.

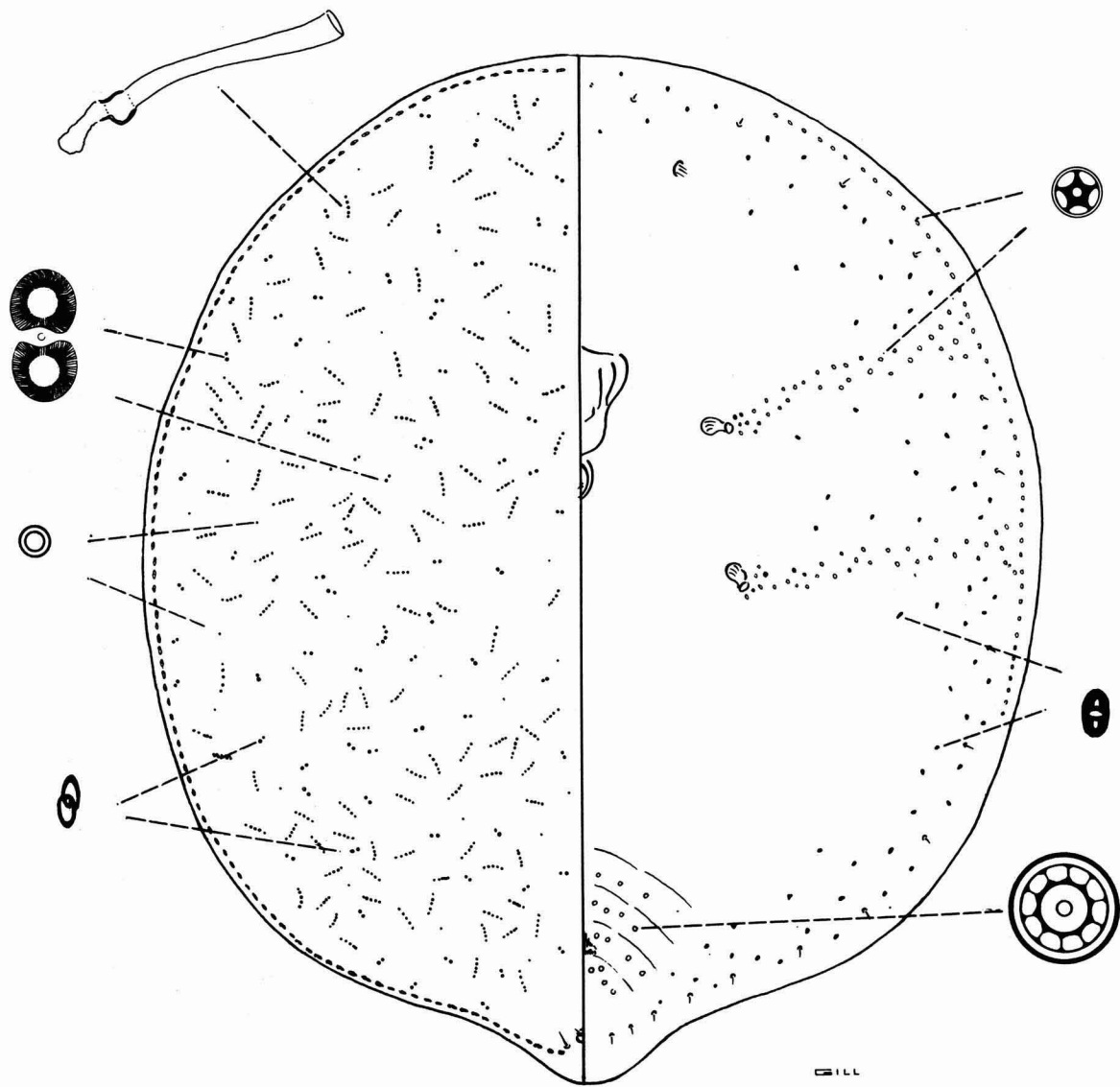


Fig. 56: *Asterolecanium quercicola* (Bouché).

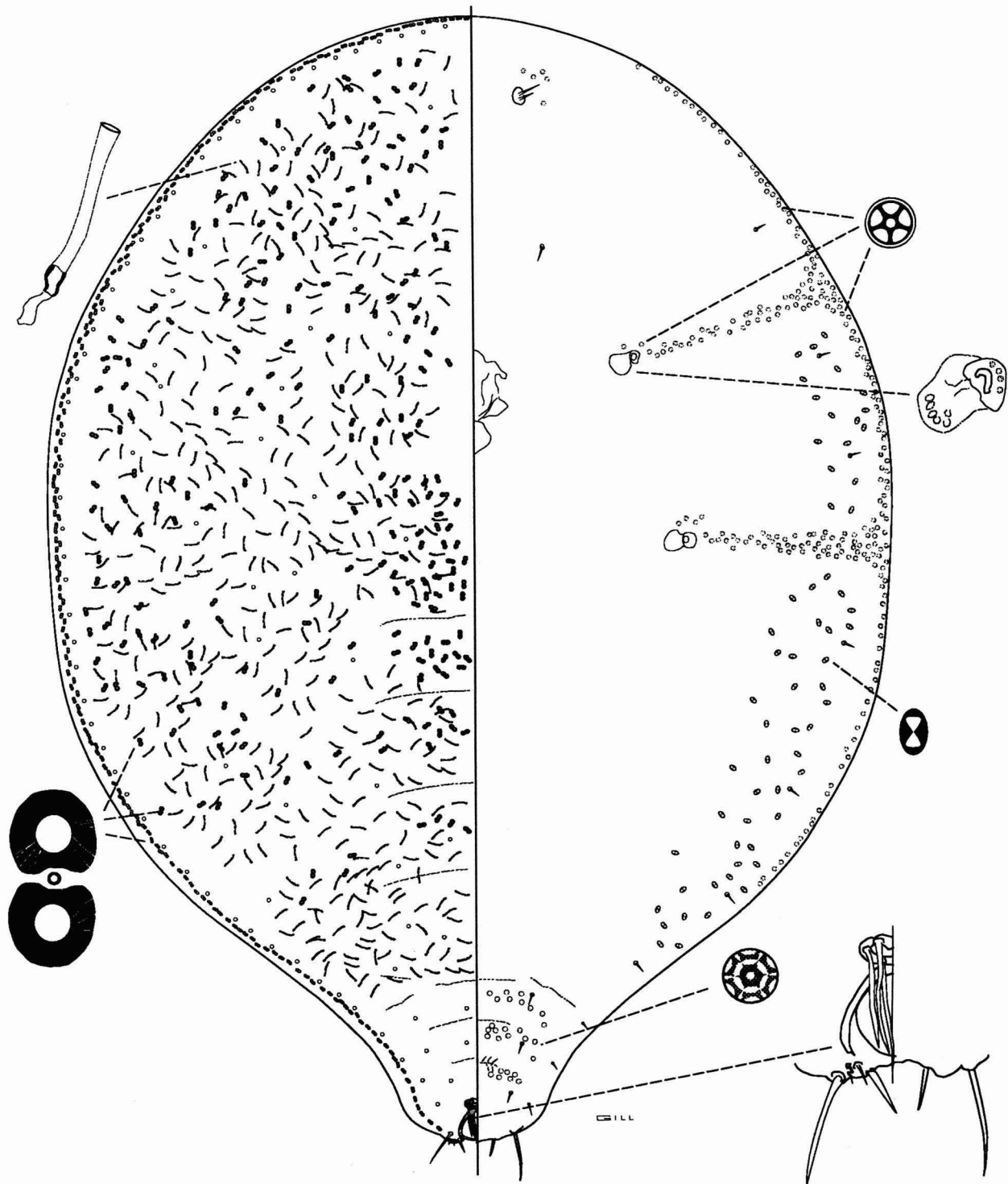


Fig. 57: *Asterolecanium stentae* Brain.

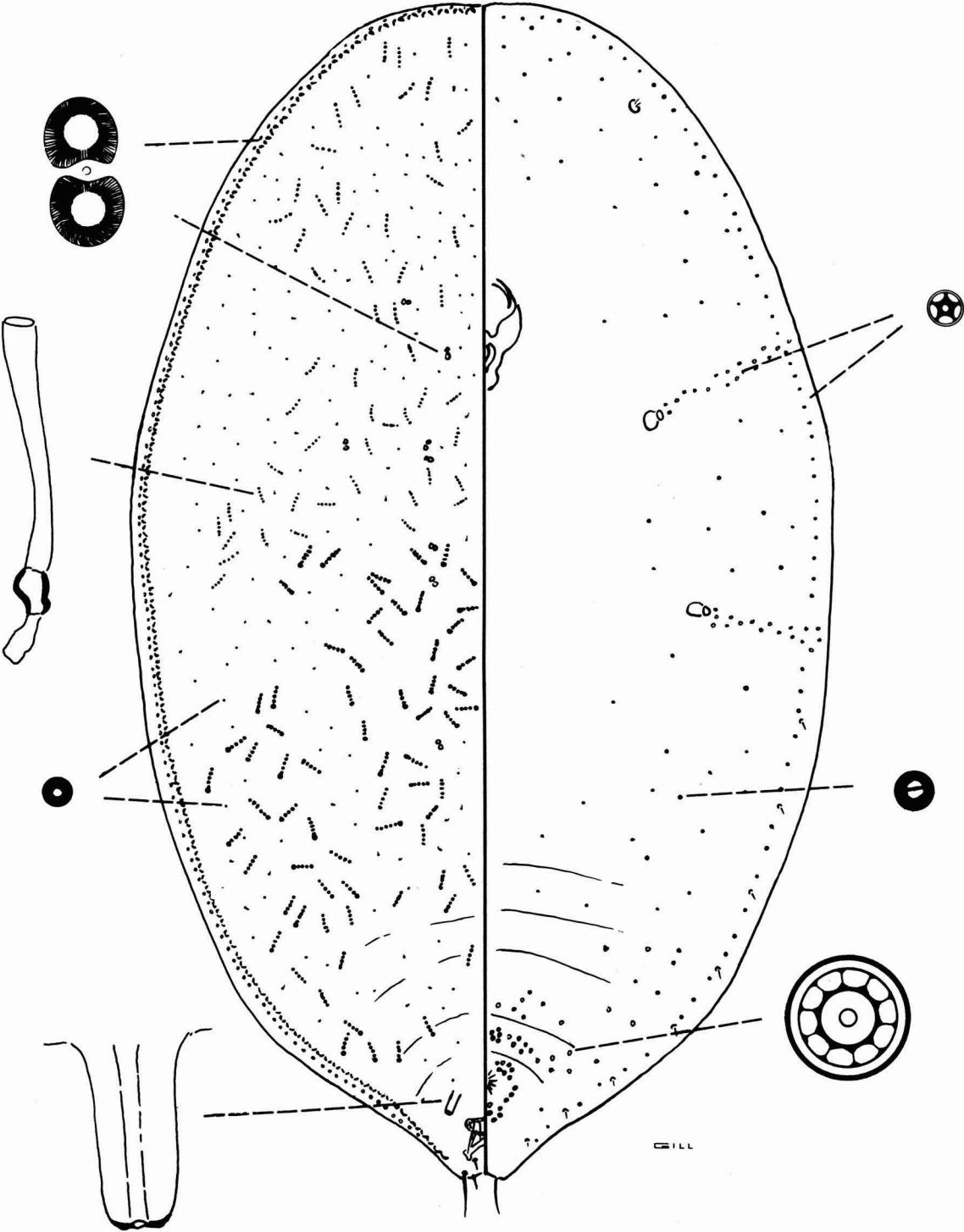


Fig. 59: *Bambusaspis bambusae* (Boisduval).

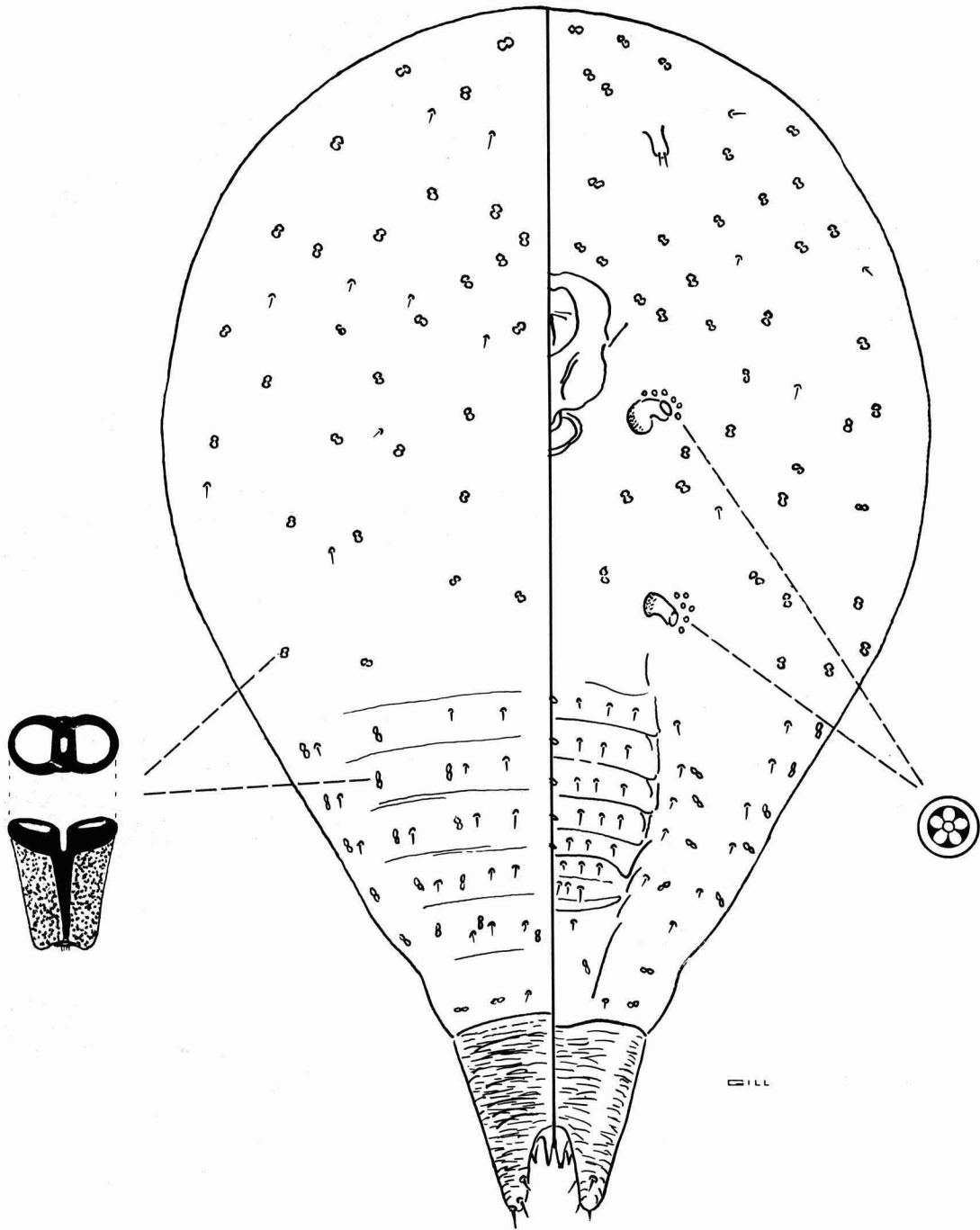


Fig. 60: *Mycetococcus ehrhorni* (Cockerell).

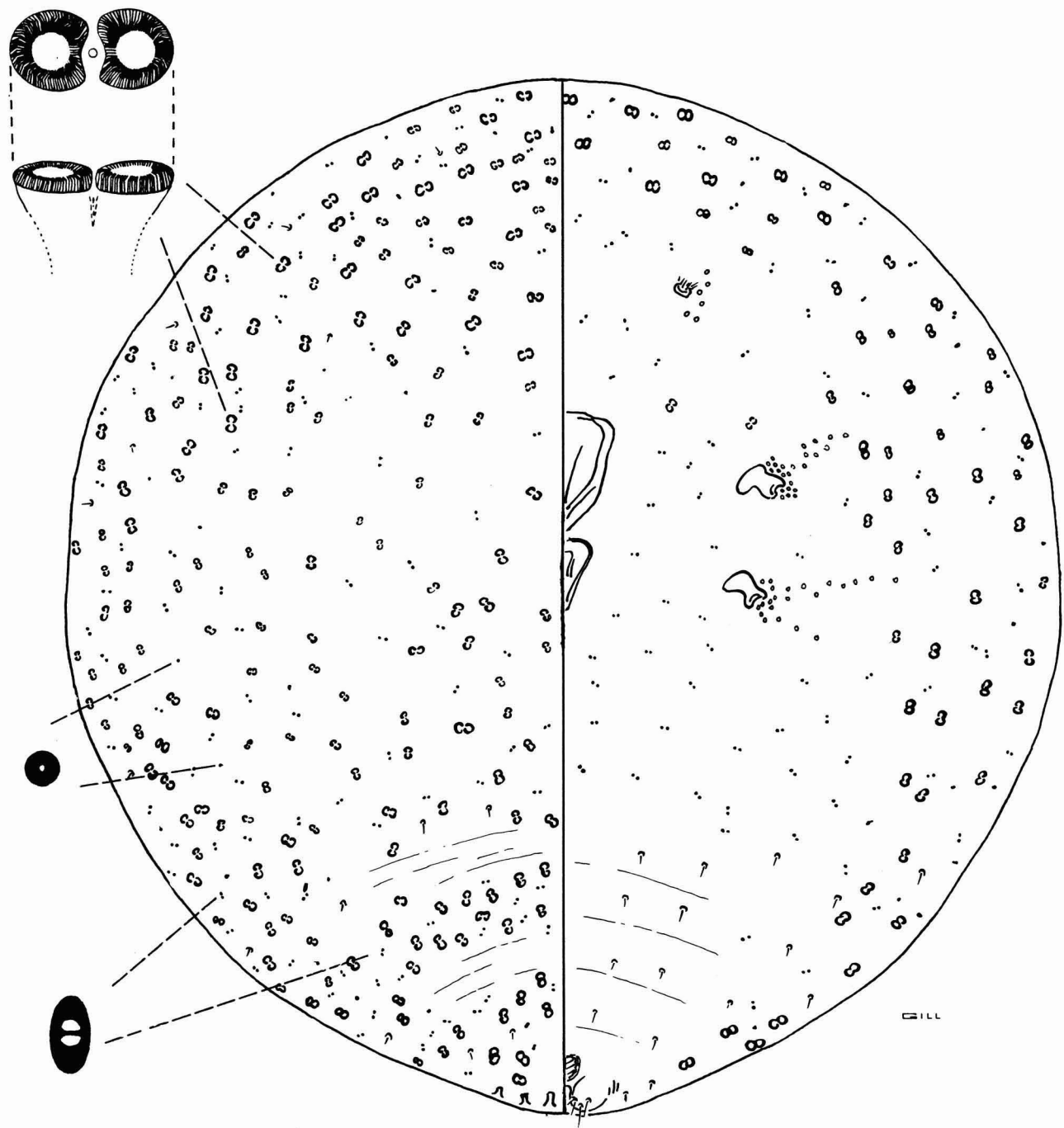


Fig. 61: *Pollinia pollini* (Costa).

FAMILY LECANODIASPIDIDAE

false pit scales

Color Plates 57-59

Once considered part of the family Asterolecaniidae, this family was established by Borchsenius in 1959. There are seven genera containing about 75 species. There is one genus with five species in the United States and three species in California.

Field Characteristics: Adult females enclosed within an oval or elliptical, leathery, tan wax test; 2.5 to 3.5 mm long. Male cocoons similar in color, but smaller and more oblong. Normally found on stems. Host restriction is the only criterion that can be used in separating the California species in the field.

Similar Species: None in California.

Economic Importance: None in California. Other species in the genus have caused injury to economically important plants in various parts of the world. Some examples are azaleas in the eastern United States, coffee in Africa, and guayule in Mexico. For more information, see Howell & Kosztarab (1972). Some members of this family produce pit-like distortions in the host, as do many members of the Asterolecaniidae.

Distribution: Worldwide.

Diagnosis: The United States and world species of *Lecanodiaspis* have been revised by Howell & Kosztarab (1972), and the Ethiopian forms have since been studied by Hodgson (1973). The world genera have been studied by Lambdin & Kosztarab (1973). Two of the California species can be separated from all others because they lack marginal spiracular setae. The morphology of *Lecanodiaspis* adult males has been studied by Afifi & Kosztarab (1967), and the first instar nymphs have been studied by Williams & Kosztarab (1970). The family is recognized by having dorsal and ventral 8-shaped pores, 7-9 segmented antennae without associated pores (Howell & Williams, 1976) and an anal cleft.

References:

- Afifi, S. and M. Kosztarab, 1967: Va. Polytech. Inst. State Univ. Res. Div., Bull. 15:1-43.
Howell, J. O. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div., Bull. 70:1-248.
Hodgson, C. J., 1973: Bull. Br. Mus. (Nat. Hist.), Entomol. 27(8):413-452.
Lambdin, P. L. and M. Kosztarab, 1973: Va. Polytech. Inst. State Univ. Res. Div., Bull. 83:1-110.
Williams, M. L. and M. Kosztarab, 1970: Va. Polytech. Inst. State Univ. Res. Div., Bull. 52:1-96.

Genus *Lecanodiaspis* Targioni-Tozzetti, 1869

Number of world species: 51.

Number of United States species: 5.

Key to the California species

1. Anterior spiracular setae always present **prosopidis**
— Anterior spiracular setae entirely absent **2**
2. Cribriform plates sometimes absent, if present, with not more than 2 per row, their surface

- with blade-like projections: setae on inner margin of anal plates short, about 12-17 μ long; anal ring with two rows of nipple-shaped pores *thamnosmae*
- Cribriform plates always present, 5 per row, plates without blade-like projections; setae on inner margin of anal plates longer, about 16-26 μ long; anal ring with three rows of nipple-shaped pores *rufescens*

THE CALIFORNIA SPECIES OF *LECANODIASPIS*

Lecanodiaspis prosopidis (Maskell), 1895
common pit scale

Fig. 62

Synonymy:

Prosopophora prosopidis Maskell,
Lecanodiaspis aescula Williams & Kosztarab,
L. celtidis Cockerell, *L. pruinosa* Hunter, *L. radiata* Cockerell, *L. tessellata* Cockerell.

Field Characteristics: Female covers about 3.0 mm long; tan or yellow to red-brown. Otherwise similar to *Lecanodiaspis rufescens* except that the corrugations on the scale cover are less apparent than in that species.

Biology: According to Howell & Kosztarab (1972), there is one yearly generation.

Similar Species: *Lecanodiaspis rufescens* and *L. thamnosmae* in California, *L. hodgsoni* Howell & Kosztarab on *Fouquieria* from Arizona, and *L. yuccae* Townsend on *Agave* and *Dasylirion* from New Mexico and Texas.

Hosts: Has a very wide host range, but prefers *Prosopis* in the arid southwest.

Economic Importance: None in California. According to Howell & Kosztarab (1972), produces pits and swellings at the point of attachment on stems and twigs of *Azalea* spp. in the eastern U.S.

Distribution: In California, known from one specimen collected from Algodones, Imperial County in 1944. Also occurs from Arizona to the Atlantic Coast and north to New York.

Diagnosis: Very similar to the other species found in the southwestern United States. However, it is the only California species with large, fleshy setae at the ends of both the anterior and posterior spiracular furrows.

Howell, J.O. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div., Bull. 70:1-248.

Lecanodiaspis rufescens (Cockerell), 1893
chamise scale

Fig. 63, Color Plates 57, 58

Synonymy:

Prosopophora rufescens Cockerell,
Lecanodiaspis rufescens Cockerell. The *Eriococcus adenostomae* of Essig (1911) is probably a misidentification of this species.

Field Characteristics: Typical of the family. Adult wax covers convex, light tan, 3.0 to 4.0 mm long; adorned with 3 to 5 longitudinal rows of low tubercles, giving a corrugated

appearance. Immature forms do not produce the wax cover and are not as visible on the plant. They are dark brown; oval; and covered with loose plates of transparent wax. Male cocoons white to tan; smaller but more oblong; with longitudinal rows of low tubercles which are more pronounced than those of the females. The most common member of the genus in California.

Biology: Unknown.

Similar Species: Other species of *Lecanodiaspis*.

Hosts: Prefers chamise (*Adenostoma fasciculatum*). Has been found on a number of hosts including olive (*Olea europaea*), *Ligustrum*, *Syringa*, *Tamarix*, and various native shrubs.

Economic Importance: None. A native species.

Distribution: In California, as far north as the Tehachapi Mountains in Kern County and Lone Pine in Inyo County. Common in the more arid regions of southern California; found eastward into Arizona, New Mexico, Texas,

and Colorado, and southward into Mexico. **Diagnosis:** Easily distinguished by the lack of marginal spiracular setae and the presence of two rows of 5 to 6 cribriform plates on the abdominal dorsum.

Essig, E.O., 1911: Pomona Coll. J. Entomol. 3(1):409-411.

Howell, J.O. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div., Bull. 70:1-248.

Lecanodiaspis thamnosmae Ferris, 1955
thamnosma scale

Fig. 64, Color Plate 59

Synonymy:

Lecanodiaspis thamnosmae Ferris.

Field Characteristics: Nearly identical to *Lecanodiaspis rufescens*, but a little smaller (2.5 to 3.0 mm long), and with a much smoother scale cover.

Similar Species: See *Lecanodiaspis rufescens*.

Biology: Unknown.

Hosts: Restricted to *Thamnosma montana* in California. Howell & Kosztarab (1972) record this species from *Berberis* in Virginia.

Economic Importance: None.

Distribution: Desert areas of San Bernardino, Riverside, and Imperial Counties. Outside

California, known only from Virginia, but probably occurs in Arizona and Mexico as well.

Diagnosis: Easily recognizable because of host restrictions, lack of spiracular setae, and the presence of only 0 to 2 cribriform plates. Males unknown.

Howell, J.O. and M. Kosztarab, 1972: Va. Polytech. Inst. State Univ. Res. Div., Bull. 70:1-248.

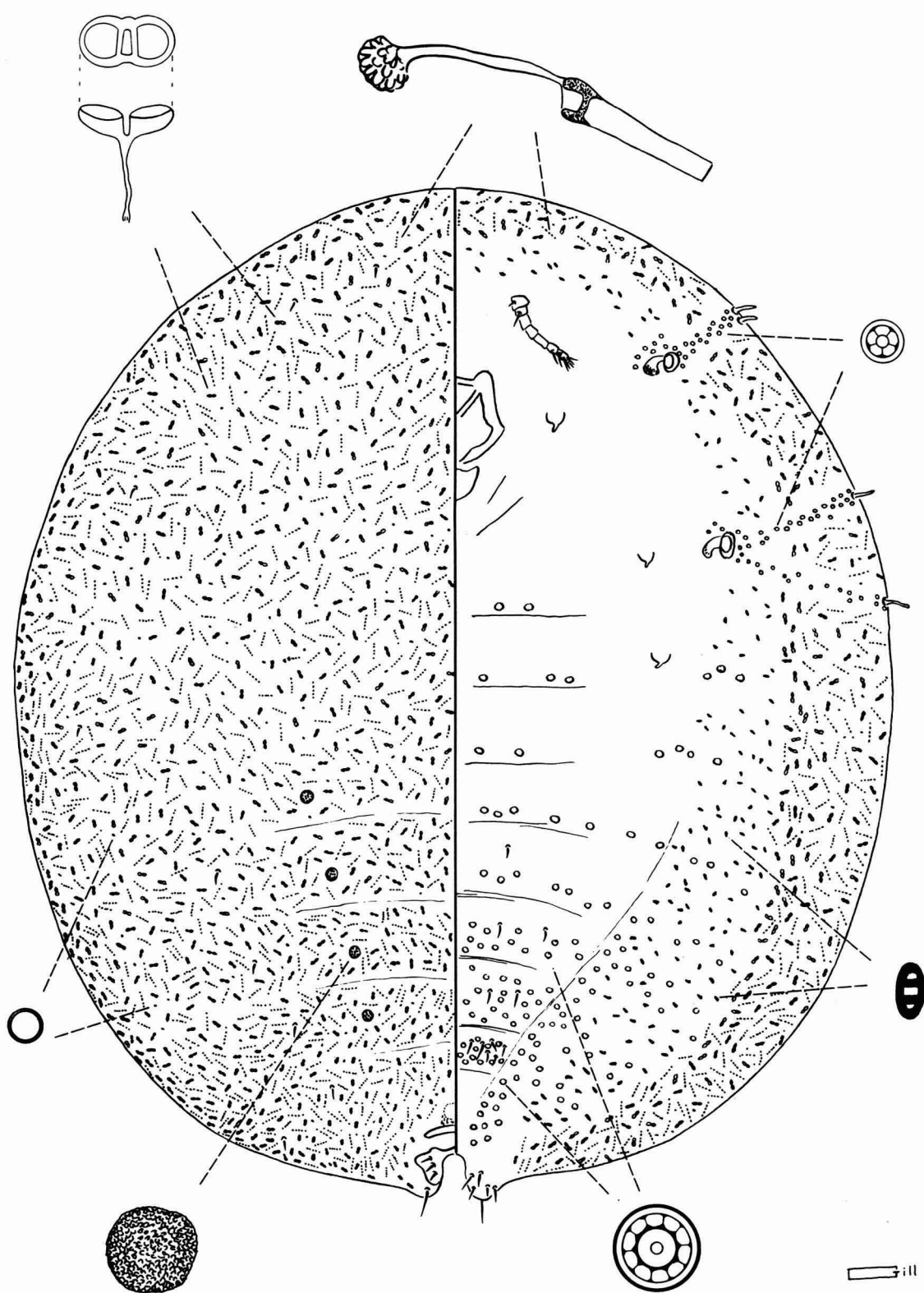


Fig. 62: *Lecanodiaspis prosopidis* (Maskell).

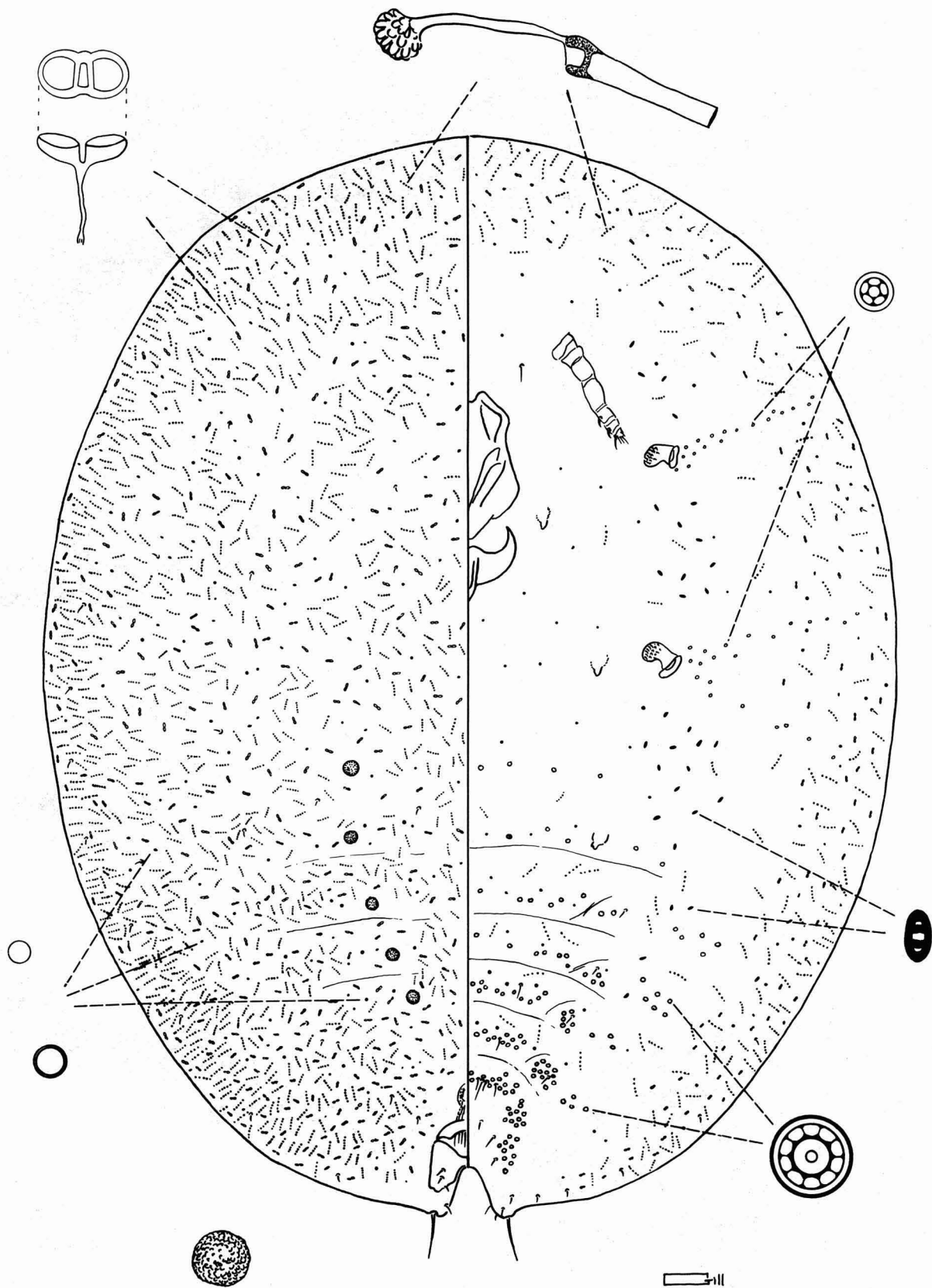


Fig. 63: *Lecanodiaspis rufescens* (Cockerell).

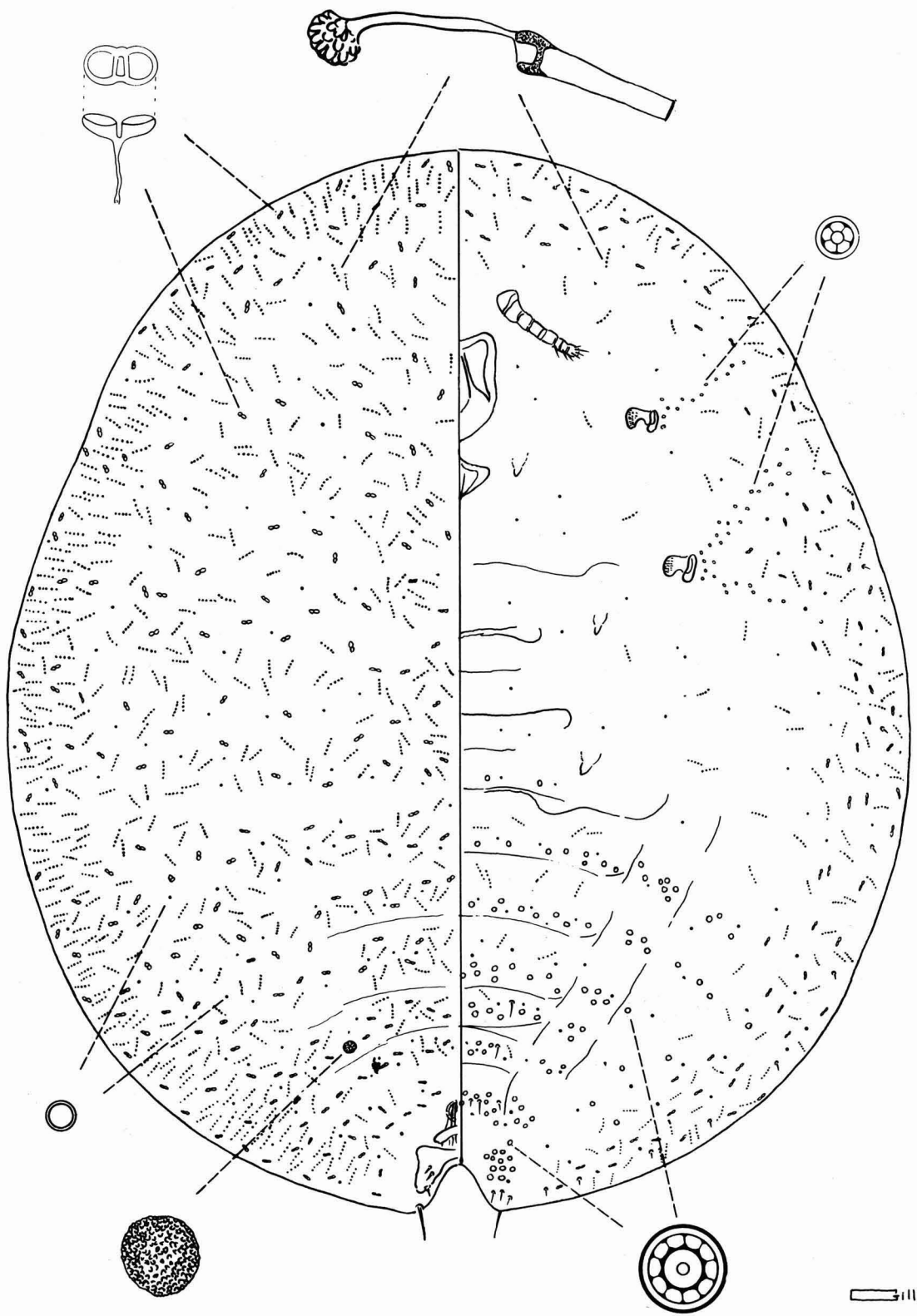


Fig. 64: *Lecanodiaspis thamnasmae* Ferris.

FAMILY CEROCOCCIDAE

cerococcins

Color Plates 60-61

This family had been considered as part of the family Asterolecaniidae until Koteja elevated it to family rank in 1974. The family contains 3 genera worldwide, with 64 species. Only the following species, oak wax scale, occurs in California.

Field Characteristics: Adult females are found within a waxen cover (test) which may be parchment-like or which, as in the case of the California representative of this family, may be gum-like in consistency. The wax tests are usually pyriform, tapering slightly posteriorly and are dorsally convex to hemispherical. The color of the test may be yellow, tan, or brown, and may be adorned with tubercles or have a stellate appearance. Male cocoons are similar to female tests in color and constituents, but are much smaller and elongate oval. All later stages are usually found on the twigs and small branches of the host.

Similar Species: False pit scales in the family Lecanodiaspididae and *Ceroplastes* wax scales in the family Coccidae are similar in the field.

Economic Importance: The one species in California is not of economic concern. One species (*C. kalmiae* Ferris) is a pest of cranberries in the eastern U.S. Another species (*C. catenarius* Fonseca) is listed as a pest of coffee in Brazil. For a summary of the economic importance of this group, see Lambdin & Kosztarab (1977).

Hosts: Most cerococcids are host specific, at least within plant families, although a few are polyphagous.

Distribution: Species are known from most temperate and tropical areas of the world. However, collections have not been made in Canada, northern South America, and equatorial Africa. *C. artemisiae* (Cockerell), known from Colorado, New Mexico, and Arizona, may eventually be found occurring naturally in southeastern California.

Diagnosis: The family is recognized by the following characteristics: dorsal and ventral 8-shaped pores, single-segmented antennae with associated cluster of multilocular pores, and a sclerotized triangular anal bar (Howell & Williams, 1976). The United States and world species of *Cerococcus* have been revised by Lambdin & Kosztarab (1977). The first instar nymphs have been studied by Hamon & Kosztarab (1979).

References:

- Hamon, A.B. and M. Kosztarab, 1979: Va. Polytech. Inst. State Univ. Res. Div., Bull. 146:1-121.
Howell, J. O. and M. L. Williams, 1976: Ann. Entomol. Soc. Am. 69(2):181-189.
Lambdin, P. L. and M. Kosztarab, 1977: Va. Polytech. Inst. State Univ. Res. Div., Bull. 128:1-252.

CALIFORNIA SPECIES OF CEROCOCCIDAE

Genus *Cerococcus* Comstock, 1882

Number of world species: 64.

Number of United States species: 4.

Cerococcus quercus Comstock, 1882
oak wax scale

Fig. 65, Color Plates 60-61

Field Characteristics: A large species, reaching 6.0 mm in length and 5.0 mm in diameter. Scale cover elliptical, convex above and flattened on the venter where it attaches to the host; bright yellow. Since the scales normally clump together on twigs, the combination of the bright color and aggregations of scales makes them highly visible. The rubbery consistency of the wax cover has resulted in the use of this scale insect as chewing gum by the Indians of the southwest (Essig, 1958). Male cocoons much smaller; oblong and sulfur-colored; found in large numbers near the females and in nearby bark cracks.

Biology: Probably one yearly generation. Overwinters as eggs. Crawlers hatched from February to May in the laboratory. See Patterson (1901).

Similar Species: None.

Hosts: Oaks (*Quercus*), particularly the low-growing desert scrub oak species.

Economic Importance: None. A native species. Has been studied as a possible source of commercial wax (Patterson, 1901).

Distribution: Southern California; Arizona.

Diagnosis: The field appearance, especially color, and host restriction and the accompanying illustration should distinguish this species.

Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.

Hamon, A.B. and M. Kosztarab, 1979: Va. Polytech. Inst. State Univ. Res. Div., Bull. 146:1- 121.

Lambdin, P.L. and M. Kosztarab, 1977: Va. Polytech. Inst. State Univ. Res. Div., Bull. 128:1-252.

Patterson, R.W., 1901: Proc. Calif. Acad. Sci. 3rd Ser. Zool. 2:387-398.

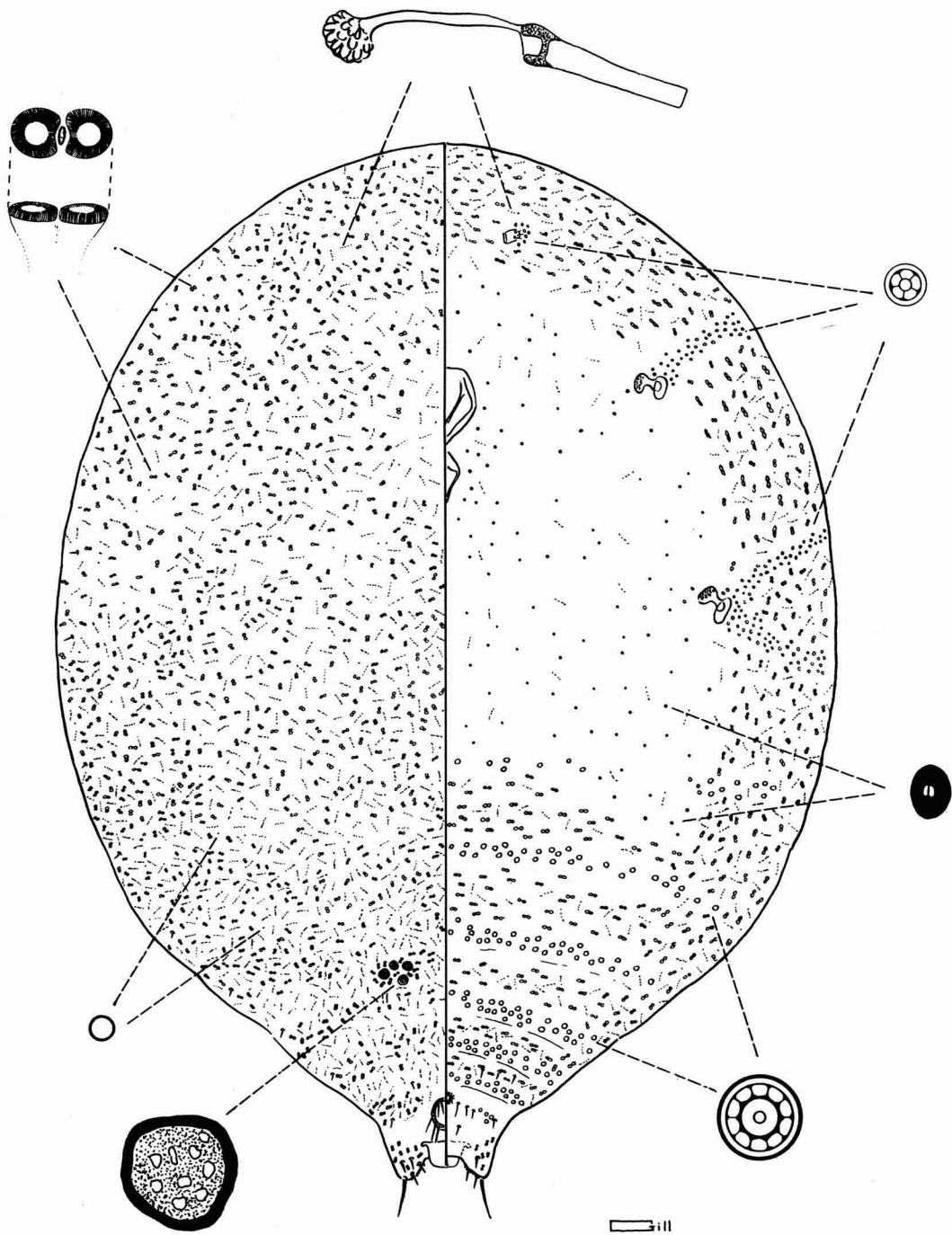


Fig. 65: *Cerococcus quercus* Comstock.

FAMILY ACLERDIDAE

Aclerids, flat grass scales, bunch grass scales

Color Plates 62-64

The aclerdid family of scale insects is a small one, containing only three genera, one of which is represented in California. They are very secretive and are seldom seen even by avid scale collectors.

Field Characteristics: On grasses, which most of the species attack, they are usually found on stems under the leaf sheaths near the crown or sometimes on the roots. Females usually pink or red, becoming orange or brown with age, usually protected by a thin, irregular, transparent wax test to which is added some opaque white mealy wax. Some honeydew is produced and the resultant sooty mold may aid in locating an infestation.

Similar Species: Some of the grass-infesting eriococcids or pseudococcids may be mistaken for this family.

Economic Importance: None reported in the United States. Some species injure sugar cane, and harvesters of *Arundo donax* reeds have reported a dermatitis condition when working with aclerdid-infested plants (McConnell, 1954).

Hosts: In the United States, primary hosts are grasses although some members of the family attack orchids, *Tillandsia*, and plants in the Cyperaceae and Combretaceae.

Distribution: Found in all geographic regions of the world, but more than half of the known species occur in North America. Although many species are known from the southwestern United States and northwestern Mexico, only two are thus far known from California. Collectors in the southeastern parts of California should watch carefully for other species which undoubtedly occur there.

Diagnosis: Taxonomy of the world species has been worked out by McConnell (1954). Slide-mounted individuals are unique in appearance and should not be confused with any other scale family. The anal operculum characteristic to the genera *Aclerda* and *Nipponaclerda* suggests some relationship to the Coccidae; but according to McConnell, they otherwise show little, if any, structural similarities to any scale insect family. This operculum is of one piece only; the operculum in the Coccidae is composed of two plates.

References

McConnell, H. S., 1954: Univ. Md. Agric. Exp. Stn. Bull. (Tech.) A-75:1-120.

CALIFORNIA SPECIES OF ACLERDA

Genus *Aclerda* Signoret, 1874

Number of world species: 50.

Number of United States species: 14.

Aclerda californica (Ehrhorn), 1897
California bunch grass scale

Fig. 66, Color Plate 62

Synonymy:

Nidularia californica Ehrhorn, *Pseudolecanium californicum* (Ehrhorn).

Field Characteristics: Adult female 2.0 to 5.0 mm long. Body red in immatures and early adult females, becoming brownish-orange to dark brown with advancing maturity; protected by an irregular, transparent to partially opaque waxen test or cell. Usually found between the stem and leaf sheath, deep within the massive crown of perennial grasses; a pick and shovel are frequently necessary collecting tools.

Similar Species: Various grass-infesting scales in the family Eriococcidae may be confused with the aclerdids because of similar body color. Most mealybugs should not be confused with aclerdids because of the lighter body color. However, the mealybug genus *Antonina*, including Rhodesgrass mealybug, *A. graminis* (Cockerell), is very similar to aclerdids, as is the mealybug genus *Discococcus*.

Hosts: Usually found on perennial bunch grasses; also on the grass genera *Elymus*, *Hordeum*, and *Melica*.

Economic Importance: None reported. How-

ever, collections of what appear to be this species from Plumas County have been extremely heavy on the host, suggesting that these scales may be deleterious to stands of perennial range grasses.

Distribution: Collected primarily near Stanford University at the south end of San Francisco Bay, and at Lancaster, Los Angeles County. Also known from Washington; probably occurs in northern California and Oregon. Tom Haig has made numerous collections of an aclerdid that may be this species from the Plumas County area.

Diagnosis: For a key to the United States aclerdids see McConnell (1954). The taxonomy of this group is in doubt in California. The specimens from Plumas differ from those collected near the type locality. Nothing has been collected in between, and it is impossible at this time to determine whether two species are involved or whether the differences are strictly regional or environmental variation.

McConnell, H. S., 1954: Univ. Md. Agric. Exp. Stn. Bull. (Tech.) A-75:1-120.

Aclerda tokionis (Cockerell), 1896
Japanese bamboo aclerdid

Fig. 67, Color Plate 64

Synonymy:

Sphaerococcus tokionis Cockerell, *Pseudolecanium tokionis* (Cockerell), *Aclerda japonica* Newstead.

Field Characteristics: Adult females 2.8 to 7.0 mm long; listed as brown in the original description, but probably dark red in young adults. Produces large amounts of white

powdery wax along the margins. Occurs between the leaf sheaths and stems of the host.

Similar Species: The noxious bamboo mealybug, *Antonina pretiosa* Ferris, is very similar, but less elongate.

Hosts: Bamboo.

Distribution: Native to Japan. Collected from bamboo by Kuwana on the Stanford University

SCALE INSECTS OF CALIFORNIA

campus on February 27, 1900. Collections made since in Los Angeles County and in the San Francisco Bay area may also be this species, but the condition of the specimens was too poor to allow positive identification.

Economic Importance: None.

Diagnosis: The following structural characteristics will aid in identifying this insect: anal operculum entire but with a shallow posterior notch; abdomen with multilocular pores on the ventral submargins; microtubular ducts

FAMILY ACLERDIDAE

on the ventral submargins only; microtubular ducts present dorsally and ventrally; abdominal disc pores in bands less than 3 pores wide. For more morphological information, see McConnell (1953).

McConnell, H. S., 1953: Univ. Md. Agric. Exp. Stn. Bull. (Tech.) A-75:1-120.

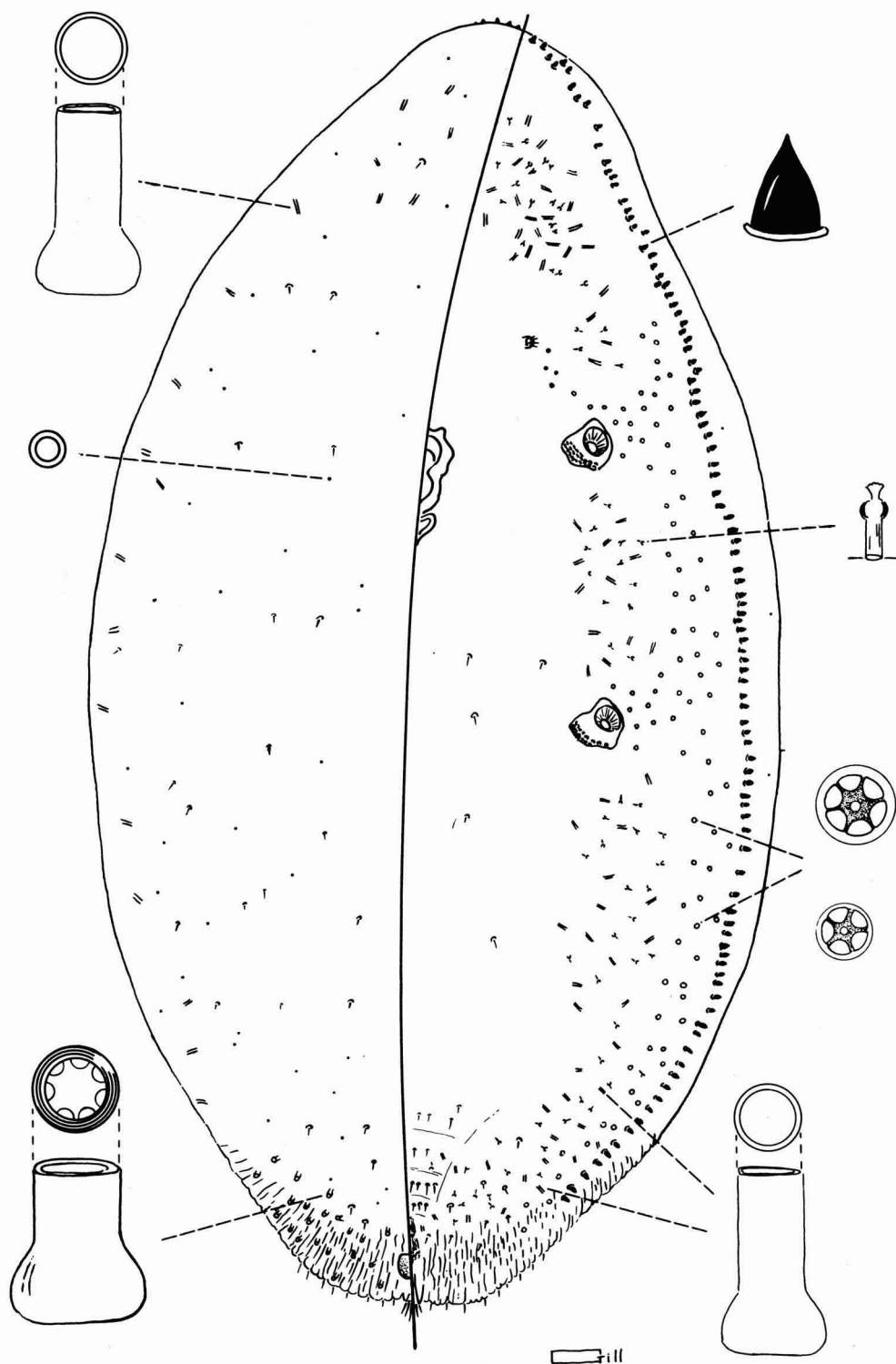


Fig. 66: *Aclerda californica* (Ehrhorn).

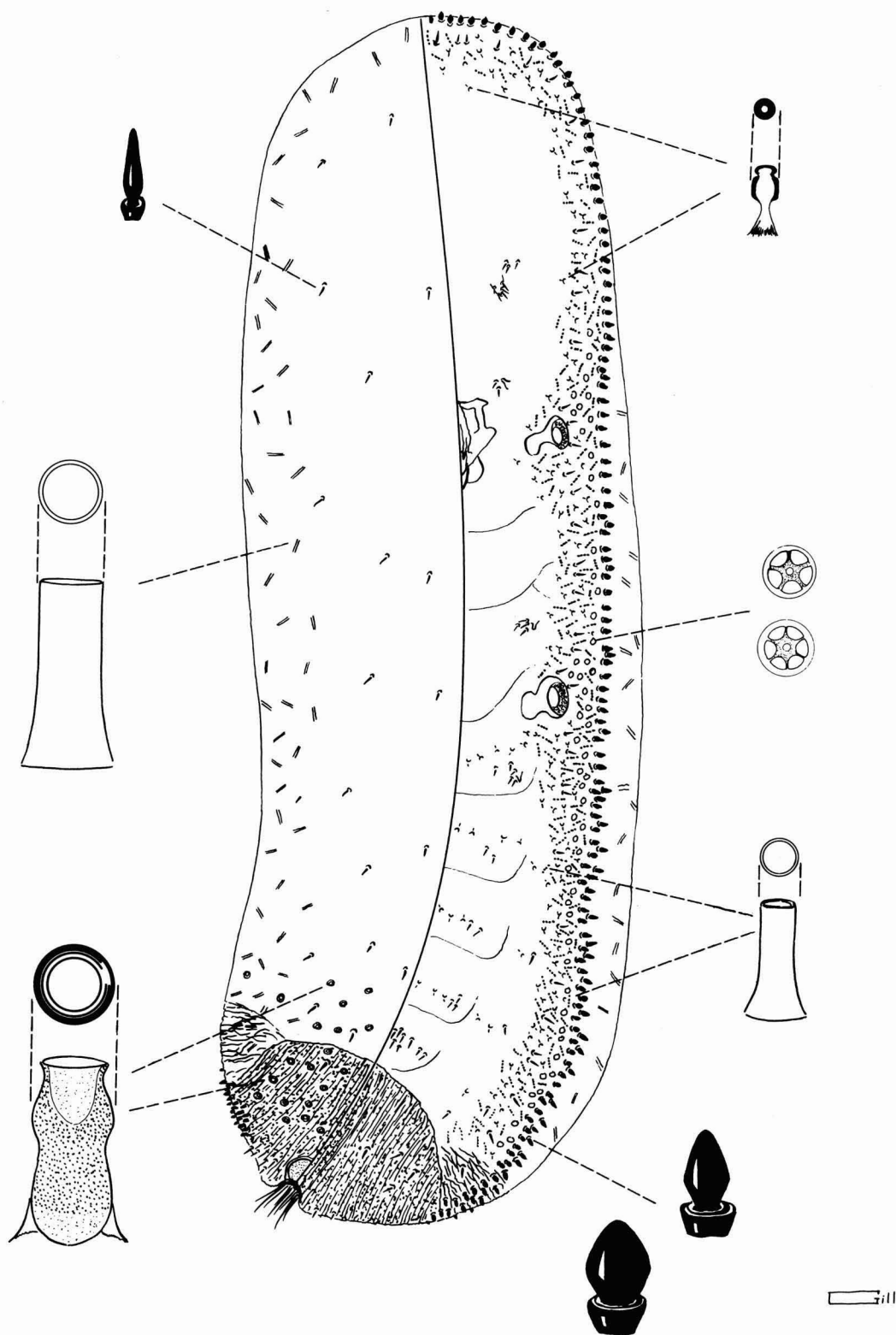


Fig. 67: *Aclerda tokionis* (Cockerell).

FAMILY KERMESIDAE
(KERMIDAE, KERMOCOCCIDAE)
gall-like scales or oak gall scales
Color Plates 65-74

The family Kermesidae was at one time included in the families Eriococcidae, Dactylopiidae and others, but recently authorities have elevated it to family rank. It has also been known by the names Kermidae and Kermococcidae.

The family is small, in North America containing about 30 species, presently in four genera. There are two genera represented in California, *Kermes* and *Allokermes*. The other two North American genera are *Nanokermes*, with three species known from Arizona and the eastern U.S., and *Ollifiella*, containing two gall-forming species from Arizona and Mexico.

The United States species have been listed by Ferris (1955) and revised by Bullington & Kosztarab (1985) and Baer & Kosztarab (1985). The research undertaken on the United States (Nearctic) species of Kermesidae by Bullington & Kosztarab (1985) and Baer & Kosztarab (1985) has been very intensive, but because of the poor condition or even loss of some of the type specimens, the true status of all of the North American forms may never be known. See comments under the Diagnosis section.

The world species have been catalogued by Hoy (1963) as part of the Eriococcidae. The current status of the world genera is discussed by Bullington & Kosztarab (1985). There are now about 68 species in 8 genera.

Field Characteristics: The Kermesidae are distinctive and host specific and should be readily recognized in the field, once one learns to distinguish them from the very similar galls caused by cynipid wasps. Scales in the genera *Kermes* and *Allokermes* resemble oak galls, but they are not galls and do not produce galls; those in the genus *Ollifiella* produce distinctive galls on oak leaves.

Essig (1915) has some excellent photographs of these insects. Adult females (post-reproductive) are sclerotized and leathery and are usually very globular to nearly spherical in shape, 4 to 7 mm in diameter and are usually found on the twigs of the host. However, females are circular in shape and flat just after the last molt; because of this shape, they closely resemble soft scales. After molting, the females immediately begin enlarging to the spherical shape typical of the group, usually reaching their full size in about a week. Full size is attained, egg laying is completed, and the females die within a few short weeks in the spring. However, the dead scales (post-reproductive females) adhere to the host for up to a year or more, and it is usually these dead scales which are noticed by collectors. The color patterns of post-reproductive females are highly variable, and their shape may also vary; unfortunately, many of the species descriptions were based on these field characteristics. The dead females are usually mottled tan or brown, and it is this form of the scale that so closely resembles cynipid wasp galls. It is easy to distinguish the two because an oak gall has a solid, corky interior, whereas a kermesid scale is hollow internally except for a powdery residue composed of internal organs, empty egg shells and a few dead crawlers. Males are usually present. They

form a loose cottony white puparium (cocoon) similar to the puparia formed by males of the Eriococcidae. The puparia are usually found on larger twigs, branches, and trunks of the host, well removed from the feeding sites of the adult females. Male nymphs are reddish-brown, tapered posteriorly, and are covered by quadrate or polygonal transparent wax plates (Color Plate 40).

Biology: Little is known about the biology of these scales, although there apparently is only one generation per year. While the biologies of the California species have not been worked out, two eastern species have been studied. See McConnell & Davidson (1959) and Hamon et al. (1976).

Similar Species: Soft scales in the genus *Parthenolecanium* are similar, but they are not spherical in shape on these hosts.

Hosts: These scales are restricted primarily to oaks in the genus *Quercus*, although at least two species are known to occur on chinquapin (*Castanopsis*), which is also in the oak family.

Economic Importance: The kermesid species are as a rule uncommon and non-economic in California. They are well controlled by natural enemies. Since the scales are cryptic when alive, they are very difficult to locate, and collecting just a few living individuals may take hours. Often the living scales are tended by ants, and it is easiest to locate them by first locating the ants. Occasionally large populations may build up on certain trees, particularly if ants are tending the scales, but injury is seldom noticeable. However, some injury from kermesids has been noted in the eastern United States and in Europe. For more information, see McConnell & Davidson (1959), Kozár (1974), Hamon (1977) and Bullington & Kosztarab (1985).

Distribution: Scales in this family are generally distributed throughout California. In the United States, most of the scales occur in California and the southwest and only five or six species occur on the East Coast. The *Kermes* group is widely distributed in the temperate Northern Hemisphere, and a few species are known from North Africa and Central Mexico. The genus *Olliffiella* is represented by two species in Arizona, New Mexico, and Mexico.

Diagnosis: The family has been revised by Michael Kosztarab, Stephen Bullington, and Ron Baer at Virginia Polytechnic Institute and State University, Blacksburg, Virginia. There were some taxonomic problems with the group because original descriptions are largely based on post-reproductive females and the type specimens themselves if still in existence are also post-reproductive females. The morphology of post-reproductive females cannot be studied because the sclerotization processes that take place during the latter part of the life of the insects completely obliterate the structures of taxonomic importance. The revision of the genus is greatly hampered by the fact that the adult female type material for many of the species therefore cannot be studied taxonomically, although it has been found that the morphology of the crawlers (first instar nymphs) taken from the type specimens has aided in establishing the identity of some of the species. The crawlers were collected by searching under the body cavity of the post-reproductive females. The taxonomy of available crawler stages and early instar nymphs has been studied by Baer & Kosztarab (1985) and a key to the species based on these stages has been presented in their publication.

The morphology of the adult females has been shown by Bullington & Kosztarab (1985) to be variable depending on the age of the specimens. For taxonomic purposes it is best to choose newly molted adults whenever possible for best accuracy in identification. Also, in older females the ventral derm becomes invaginated, so that there is a true venter and a false venter. Locating morphological structures on these two separate surfaces becomes extremely difficult in slide mounted specimens. A list of those species recorded from California but still of uncertain taxonomic status appears at the end of this chapter (page 135).

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Key to California Kermesidae
by Stephen Bullington

(based on slide mounted pre-reproductive adult females only)

- 1. Dorsum with heavily sclerotized, 8-shaped to elongate, tooth-shaped structures or spinescent pores (Fig. 6), these ranging from 4μ to 39μ; multilocular disc pores, if present, lateral and not covering entire dorsum, evenly distributed in marginal row (Figs. 68-72) – (**Genus *Allokermes***) 2
- Dorsum without spinescent pores; multilocular disc pores always present laterally and, if not covering entire dorsum, then clustered about marginal setae (Figs. 74-76) -- (**Genus *Kermes***) 6

- 2. Pre-anal row of multilocular disc pores not extending dorsally as far as anal ring (Figs. 68, 69) 3
- Pre-anal row of multilocular disc pores extending dorsally at least as far as anal ring (Figs. 70, 71) 4

- 3. Lateral row of multilocular disc pores present (Fig. 68); spinescent pores with median tooth; spinescent pores distributed in 3 transverse bands on mid-dorsum *branigani*
- Lateral row of multilocular disc pores absent; spinescent pores without teeth (Fig. 69); spinescent pores distributed evenly on mid-dorsum *essigi*

- 4. Pre-anal row of multilocular disc pores extending dorsally to above anal ring, encircling it (Fig. 70) 5
- Pre-anal row of multilocular disc pores extending dorsally to anal ring, but not above it (Fig. 71) *galliformis*

- 5. Lateral row of multilocular disc pores present (Fig. 70); spinescent pores with small teeth *ferrisi*

- SCALE INSECTS OF CALIFORNIA
FAMILY KERMESIDAE
- Lateral row of multilocular disc pores absent; spinescent pores without teeth (Fig. 72). *rattani*
 - 6. Mid-dorsum without multilocular disc pores 7
 - Mid-dorsum with many multilocular disc pores distributed evenly and densely (Fig. 76) *shastensis*
 - 7. Pre-anal row of multilocular disc pores without prolongations posteriolaterally; false venter without median lobe posteriorly (Fig. 74) *nudus*
 - Pre-anal row of multilocular disc pores with 3 prolongations posteriolaterally, each prolongation apically with ca. 20 multilocular disc pores surrounding 2 or 3 setae; false venter with small median lobe posteriorly (Fig. 75) *rimarum*

THE CALIFORNIA SPECIES OF KERMESIDAE

Genus *Allokermes* Bullington & Kosztarab 1985

Number of North American species: 12.
Key to U.S. species: Bullington and Kosztarab (1985).

Allokermes branigani (King), 1914
Branigan's kermes

Fig. 68, Color Plate 65

Synonymy: collected at the Paragon (Bath) placer mine at Foresthill, Placer County; re-described from specimens collected there in 1975. Generally distributed in central and northern California from Tuolumne to Siskiyou Counties.

Kermes branigani King, *Kermes nigropunctatus* Ehrhorn and Cockerell (mis-identification).

Hosts: *Quercus chrysolepis*.

Distribution: Described from specimens first

Allokermes essigi (King), 1913
Essig's kermes

Fig. 69, Color Plates 66-69

Synonymy: *wislizenii*.

Kermes essigi King, *Kermes nigropunctatus* Ehrhorn and Cockerell (misidentification), *Talla nigripunctata* Ehrhorn and Cockerell (misidentification).

Distribution: Type collection was made in Santa Paula Canyon, Ventura County; recollected there in 1975. Generally distributed in California.

Hosts: *Quercus agrifolia*, *Q. kelloggii*, and *Q.*

Allokermes ferrisi Bullington and Kosztarab, 1985
Ferris' kermes

Fig. 70, Color Plate 70

Hosts: Known only from *Quercus* spp. in California. Known from *Q. emoryi* and *Q. gambelii* in New Mexico.

Distribution: Known from Kings and San Joaquin Counties. Also occurs in Arizona, Colorado and New Mexico.

Allokermes galliformis (Riley), 1881
pin-oak kermes

Fig. 71

Other Common Names:
gall-like kermes.

Synonymy:

Kermes galliformis Riley, *Kermes waldeni* King, *Coccus galliformis* (Riley), *Talla galliformis* (Riley), *Talla waldeni* (King), *Kermes emoryi* Ferris.

Hosts: Known from many species of *Quercus*

including: *agrifolia*, *arizonica*, *chrysolepis*, *douglasii*, *durata*, *emoryi*, *lobata*, and *oblongifolia*.

Distribution: Generally distributed in California from Los Angeles north to Sonoma County. Occurs throughout the southern half of the U.S. and south into Mexico.

Allokermes rattani Ehrhorn, 1911
Rattan's kermes

Fig. 72

Hosts: *Quercus douglasii*, and chinquapin Loma Prieta Mountain, Santa Clara County. (*Chrysolepis chrysophylla* and *C. sempervirens*). Also known from Putah Creek, Solano

Distribution: Originally described from County and Mammoth Lakes, Mono County.

Genus "Eriococcus"

The species that belongs in this category, *Eriococcus gillettei* Tinsley, was placed in the Eriococcidae, genus *Eriococcus*, and for all outward appearances belongs there. However, Miller (1983) has discovered numerous differences between *E. gillettei* and the eriococcids, and feels that it should be placed here in the Kermesidae. Differences include the presence of simple discoidal pores (absent in the Eriococcidae); ventral abdominal multilocular pores with 10 loculae (never more than 9, usually 7 or less in Eriococcidae); no microtubular ducts (present in Eriococcidae); first instar nymphs with one fewer row of setae than the Eriococcidae; and males totally different, particularly in the formation of the eyes.

"Eriococcus" gillettei Tinsley, 1899
Gillette eriococcin

Fig. 73, Color Plate 71

Synonymy:

Eriococcus gillettei Tinsley, *Nidularia gillettei* (Tinsley).

Hosts: Juniper.

Distribution: Generally distributed in California, the western United States, and along the East Coast of the United States.

Economic Importance: None.

Diagnosis: The great morphological similar-

ity to the Eriococcidae immediately separates this species from the other species in the Kermesidae. Separation characters between this species and the Eriococcidae are mentioned above. There has not been an assignment of a new generic name at the time of this writing, but there is a paper currently in press by D. R. Miller which will solve this problem.

Genus *Kermes* Boitard, 1828

Number of world species: Approximately 65.

Number of North American species: 4.

Key to U.S. species: Bullington and Kosztarab (1985).

Kermes nudus Bullington and Kosztarab, 1985
chinquapin kermes

Fig. 74, Color Plate 72

Hosts: Known only from chinquapin, Creek, El Dorado County, Yosemite, (Chrysopsis chrysophylla and C. sempervirens). Tuolumne County, and Mammoth Lakes,

Distribution: Known only from Shingle Mill Mono County.

Kermes rimarum Ferris, 1955
bark crevice kermes

Fig. 75, Color Plate 73

Hosts: Known from the following species of *Quercus*: *douglasii*, *durata*, *gambelii*, *garryana*, and *lobata*. San Joaquin Valley and in the coastal mountains from Santa Barbara north to Sonoma County. Also known from Arizona, Oregon and New Mexico.

Distribution: Common in central and southern California. Particularly common in the

Kermes shastensis Ehrhorn, 1911
cottony kermes

Fig. 76, Color Plate 74

Hosts: *Quercus chrysolepis*, *Q. turbinella*, and chinquapin (*Chrysolepis*). Recollected from the type locality in 1976. Also confirmed from Tuolumne and Humboldt Counties.

Distribution: Originally described from Shasta Springs, Siskiyou County, in 1911.

SPECIES OF UNCERTAIN POSITION

The following species of Kermesidae previously listed from California are known only from unidentifiable, post-reproductive females or the type specimens have not been located. These species are considered to be of uncertain status and may never be properly placed in the family:

Kermes austini Ehrhorn, 1899

Austin's kermes

Synonymy:

Talla austini (Ehrhorn), *Kermes galliformis* (Riley)(misidentification).

Hosts: Recorded only from *Quercus oblongifolia*, although this is probably in error since that plant is not known to occur in California.

Distribution: Known only from the original description from the Quejito Mountains, 8 miles east of Escondido, San Diego County.

Kermes cockerelli Ehrhorn, 1898

Cockerell's kermes

Synonymy:

Coccus cockerelli (Ehrhorn), *Talla cockerelli* (Ehrhorn).

Hosts: *Quercus lobata*.

Distribution: Type material collected at Mountain View, Santa Clara County in 1898. Recent attempts to recollect it at this location have failed. However, based on crawlers taken from type material, data indicate that this species is widespread in central and northern California and Oregon.

Kermes mirabilis King, 1914

mirabilis kermes

Synonymy:

Talla mirabilis (King), *Kermes rattani* Ehrhorn (misidentification).

Hosts: *Quercus* species.

Distribution: Known only from the original collection at Mountain View, Santa Clara County in 1914.

Diagnosis: Ferris (1955) considers this a synonym of *K. rattani*, and based on type localities this is also suspected by Bullington & Kosztarab (1985).

Kermes nigropunctatus Ehrhorn & Cockerell, 1898

black-punctured kermes

Synonymy:

Talla nigropunctata (Ehrhorn & Cockerell).

Hosts: *Quercus* species.

Distribution: Originally collected in Los Angeles. Other collection records are open to question.

Diagnosis: Bullington & Kosztarab (1985) believe this species is a synonym of *Allokermes essigi*.

Kermes occidentalis King, 1913

western kermes

Synonymy:

Talla occidentalis (King).

Hosts: *Quercus* species.

Distribution: Known only from the original collection somewhere in "California."

Kermes sassceri King, 1914

Sasscer's kermes

Synonymy:

Talla sassceri (King).

Hosts: *Quercus rubra*.

Distribution: The type locality is Laurence, Massachusetts. The California records listed by Essig (1915) are questionable.



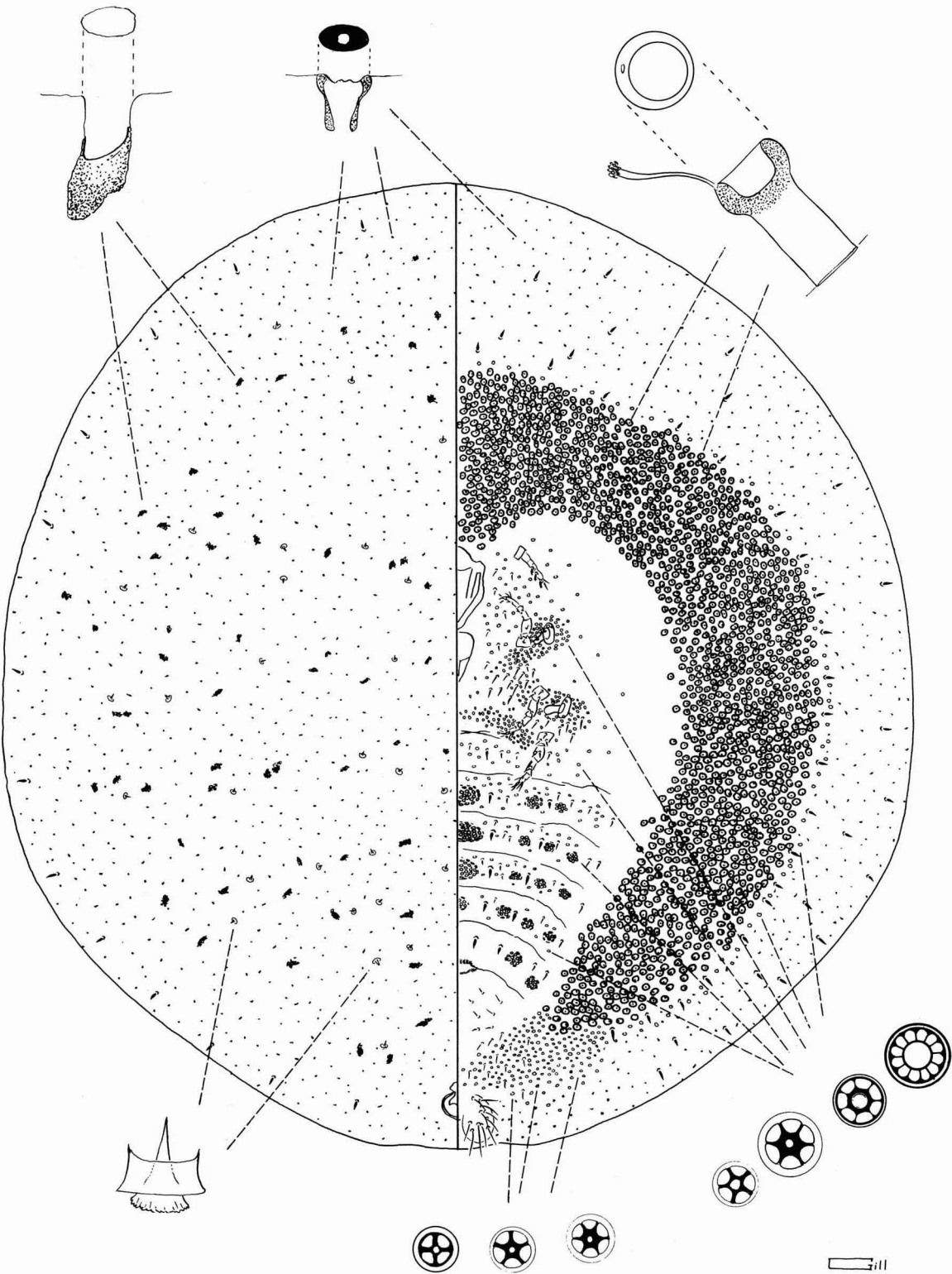


Fig. 68: *Allokermes branigani* (King).

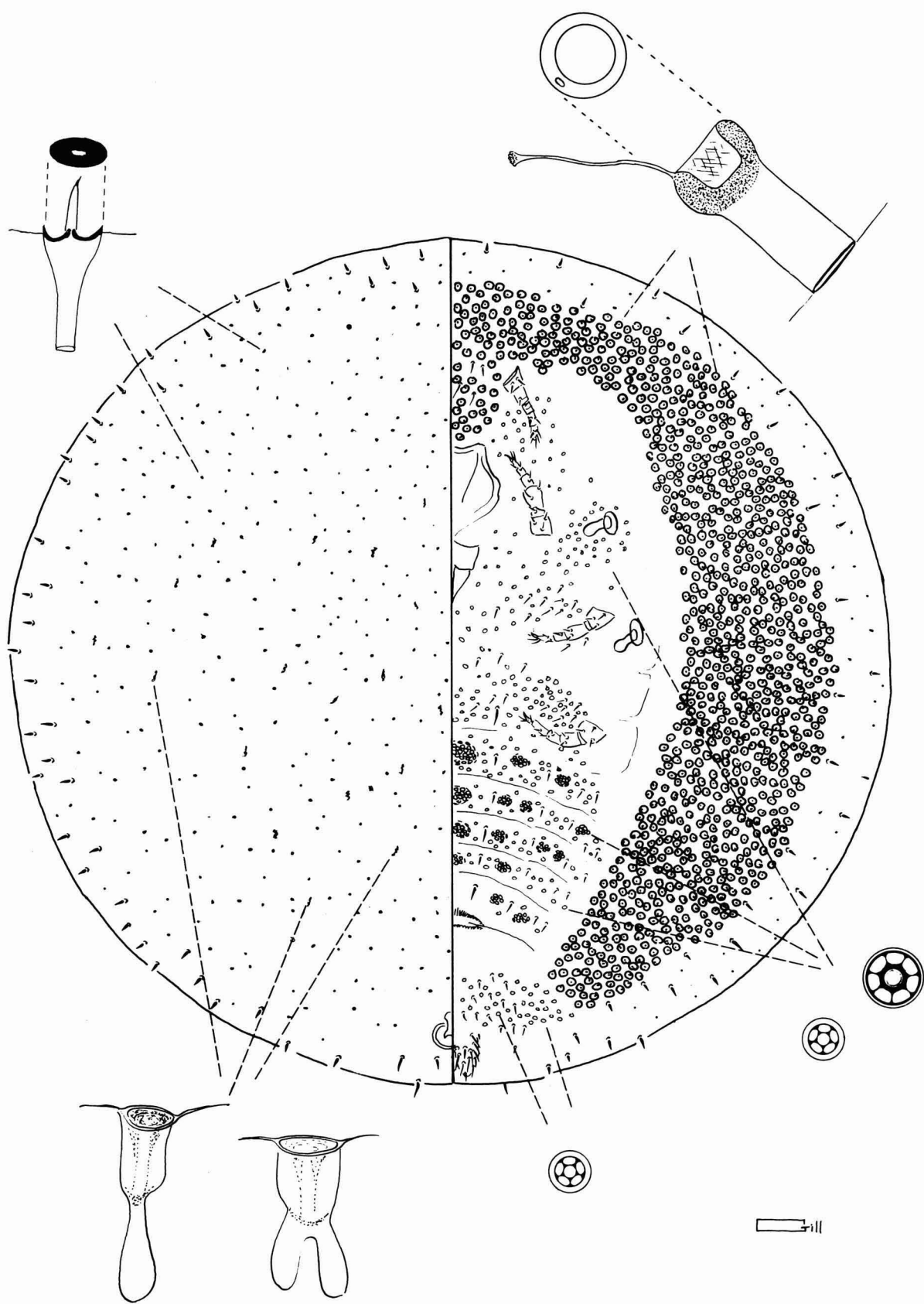


Fig. 69: *Allokermes essigi* (King).

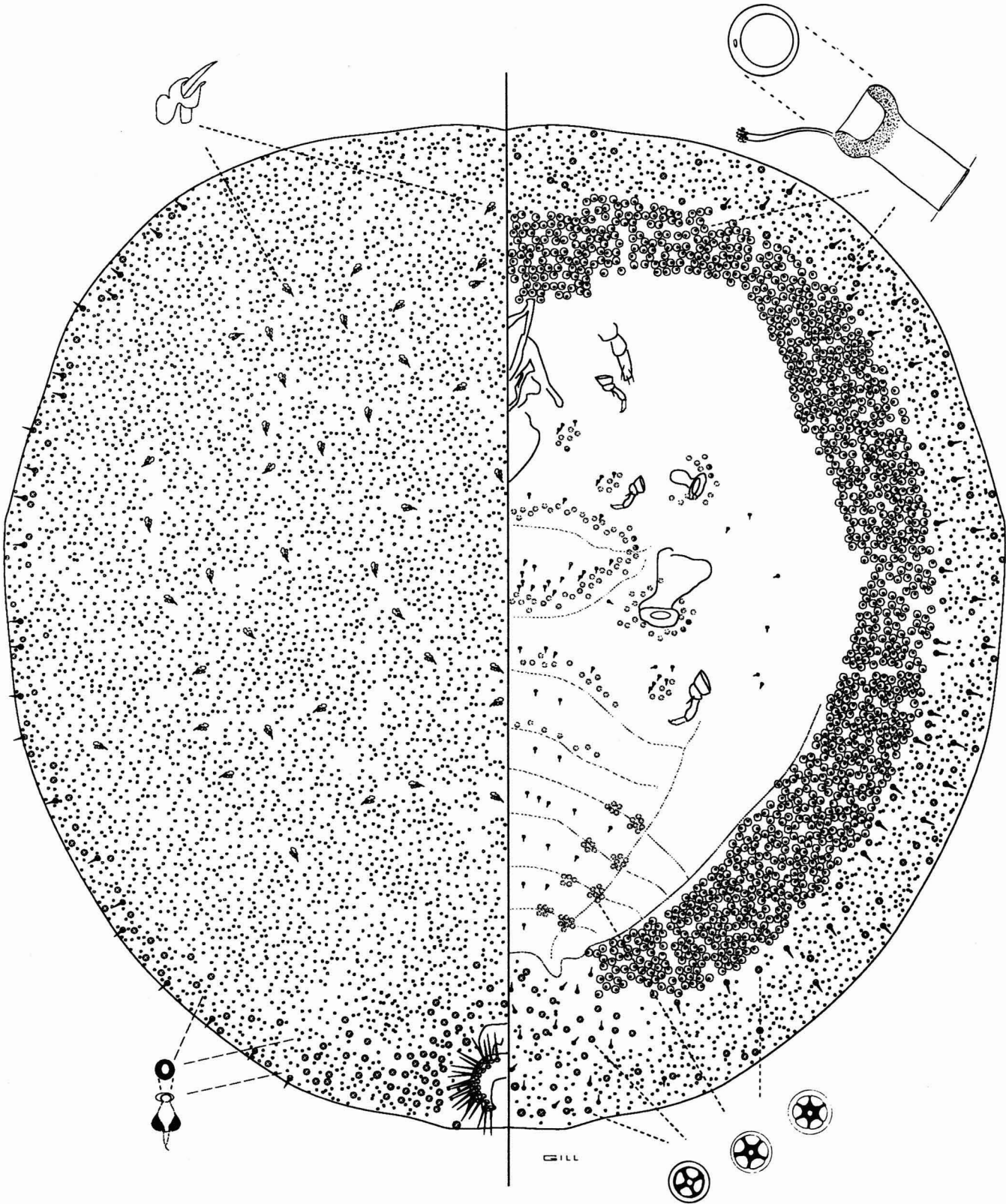


Fig. 70: *Allokermes ferrisi* Bullington & Kosztarab.

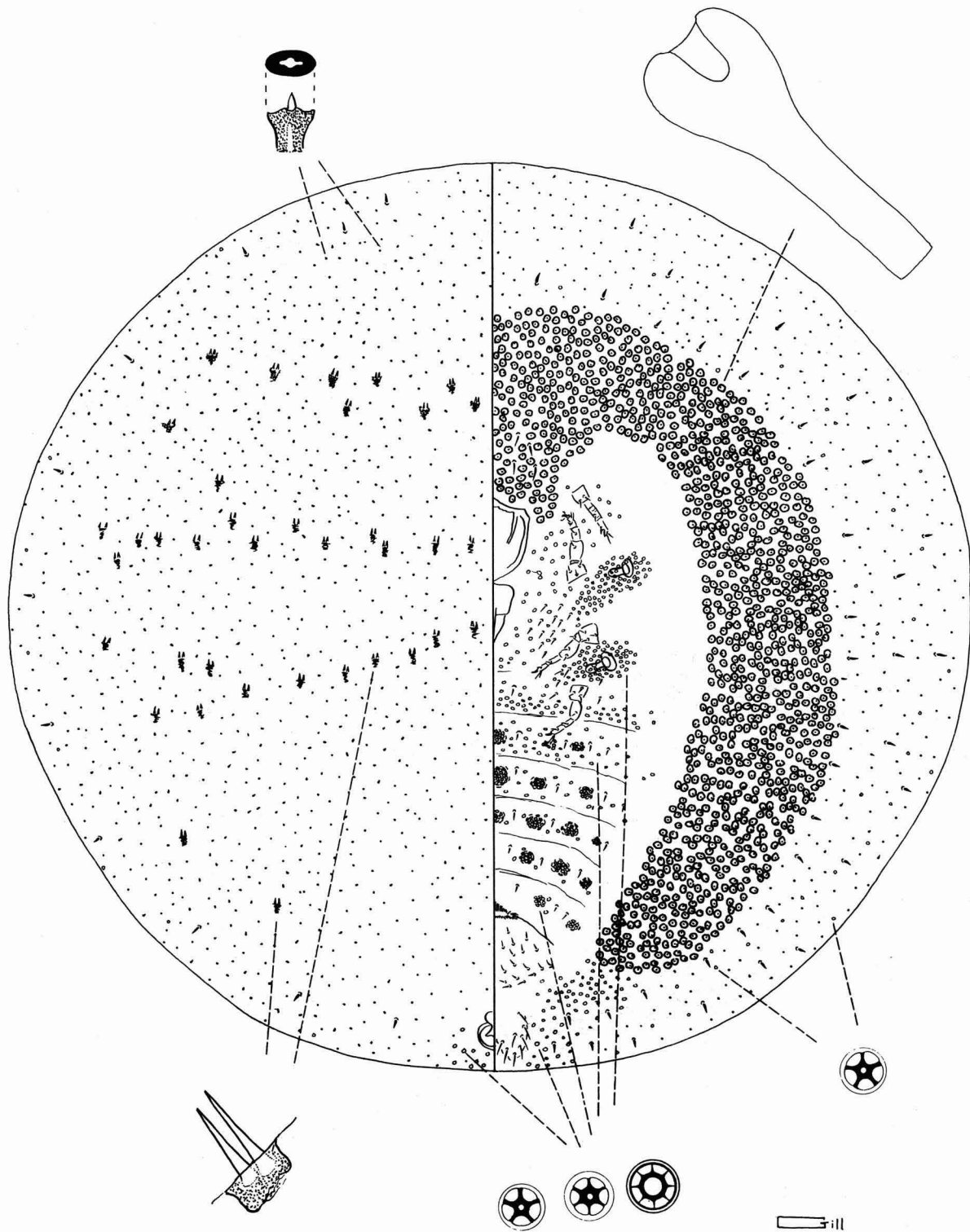


Fig. 71: *Allokermes galliformis* (Riley).

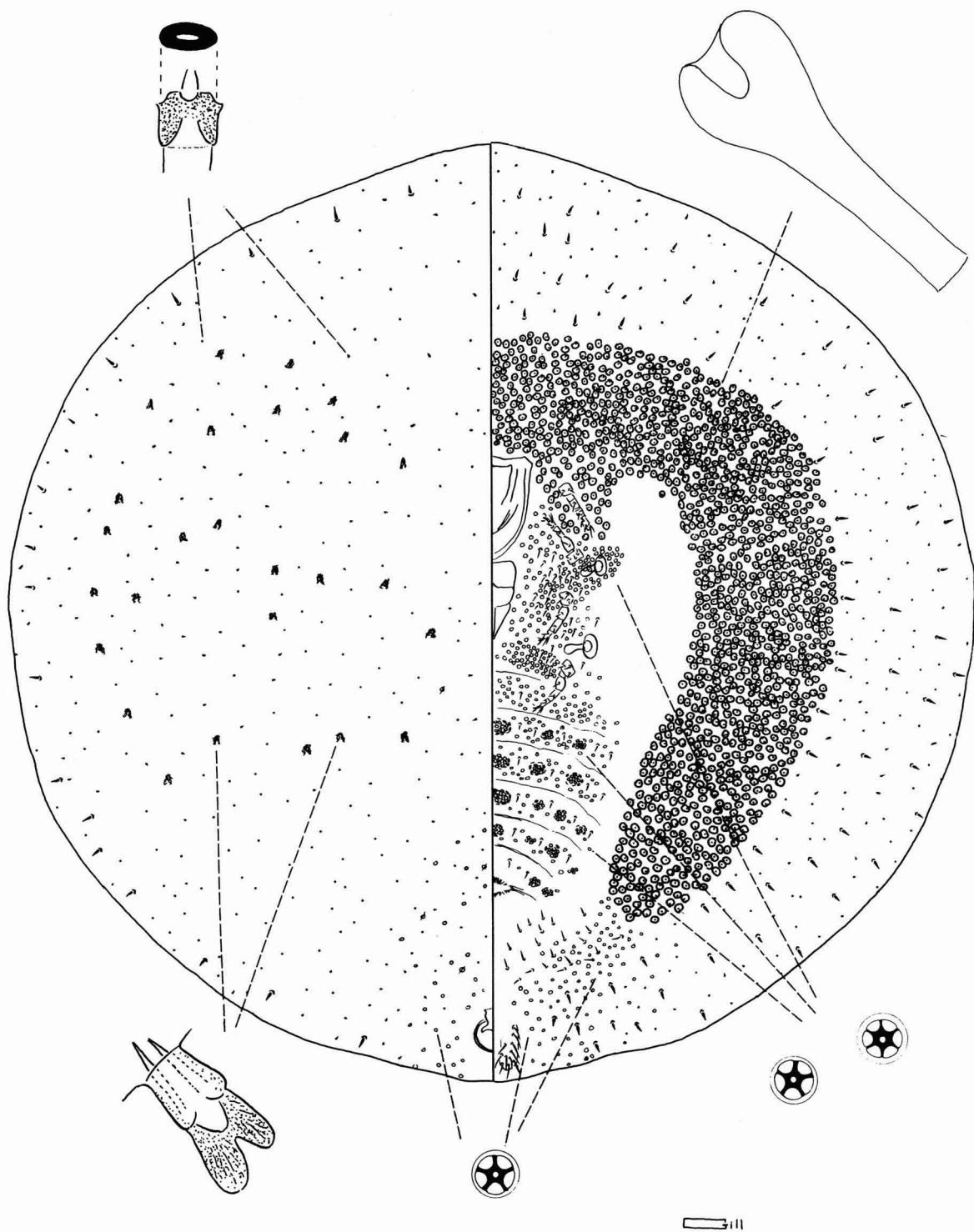


Fig. 72: *Allokermes rattani* Ehrhorn.

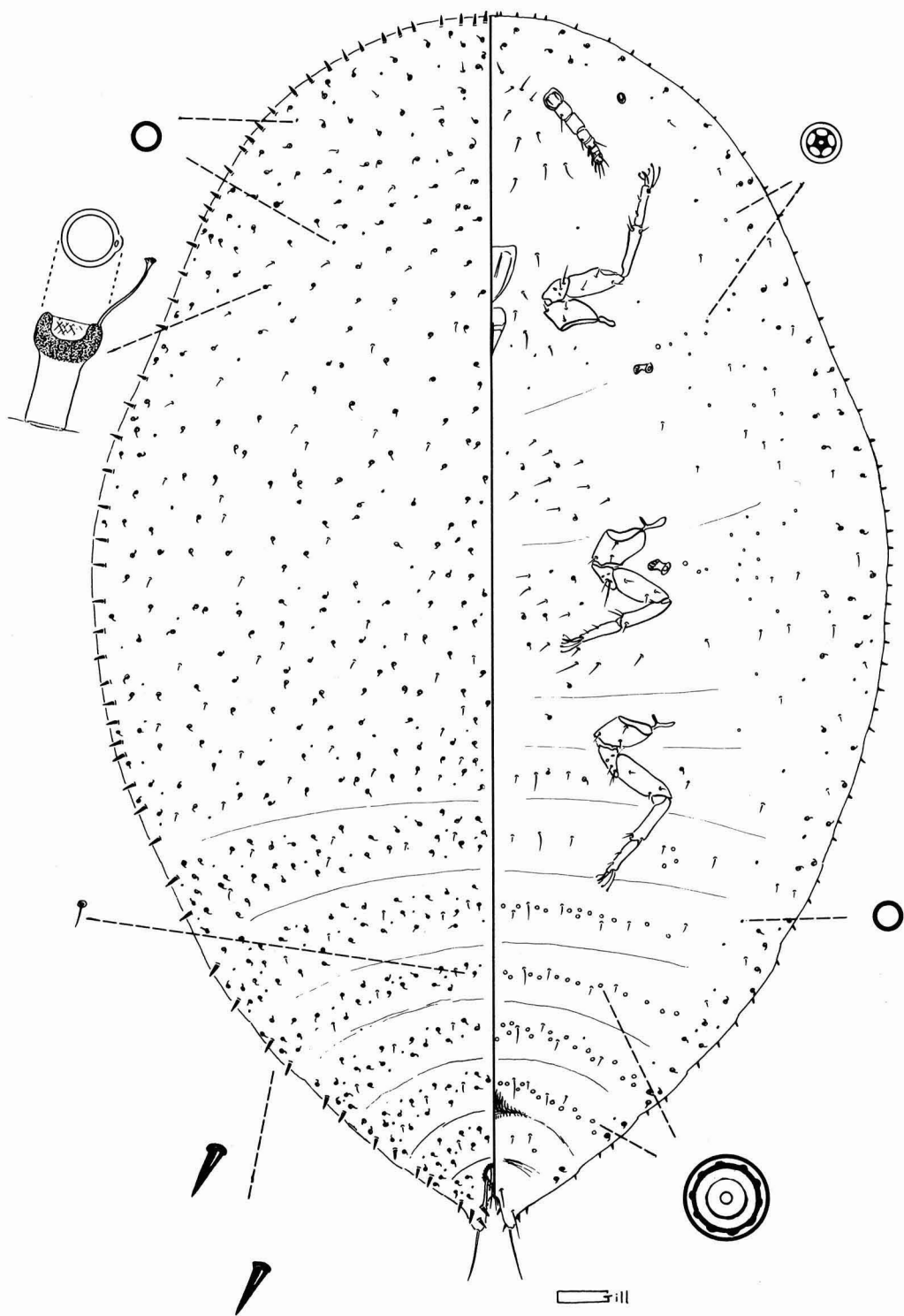


Fig. 73: "*Eriococcus*" *gillettei* Tinsley.

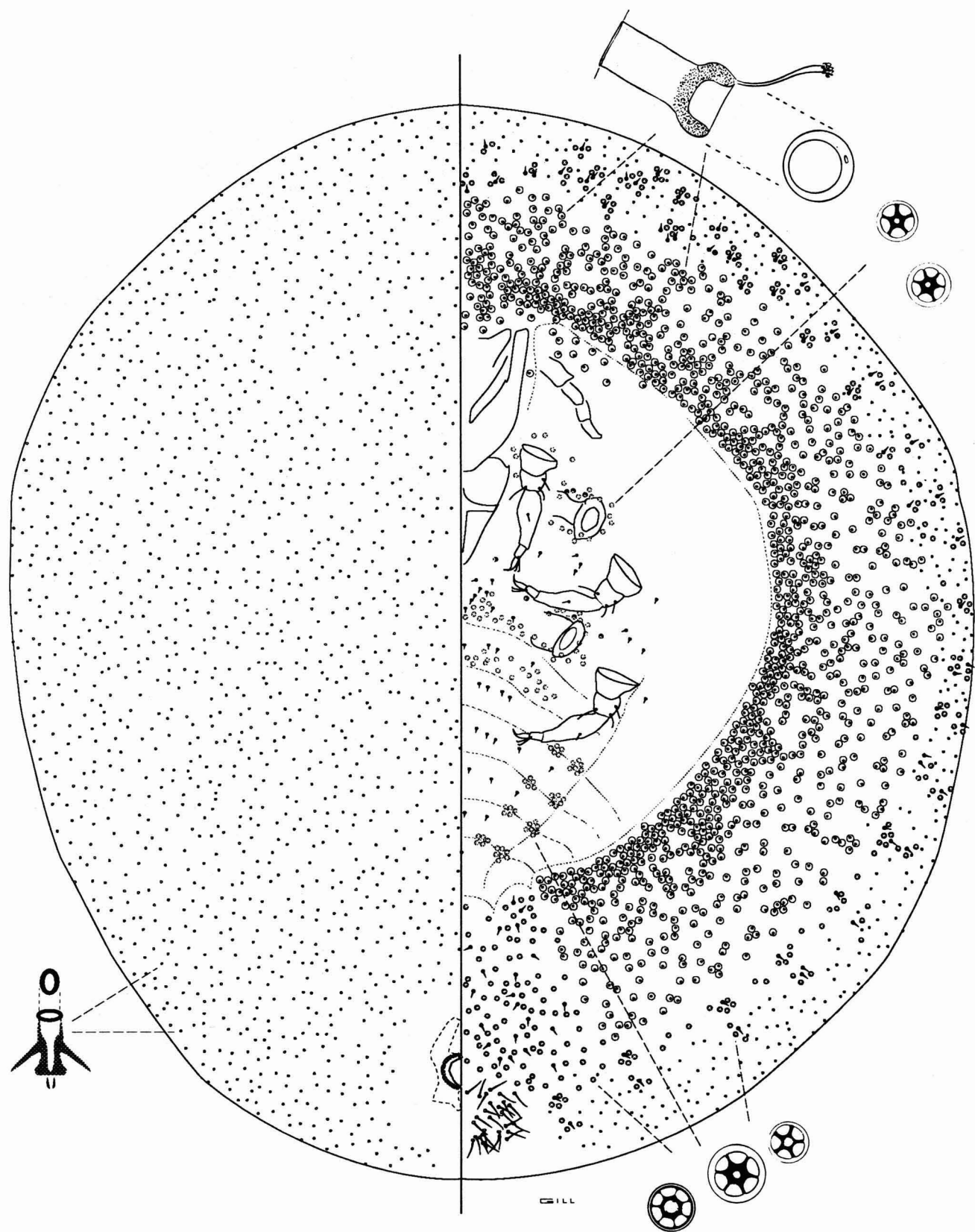


Fig. 74: *Kermes nudus* Bullington & Kosztarab.

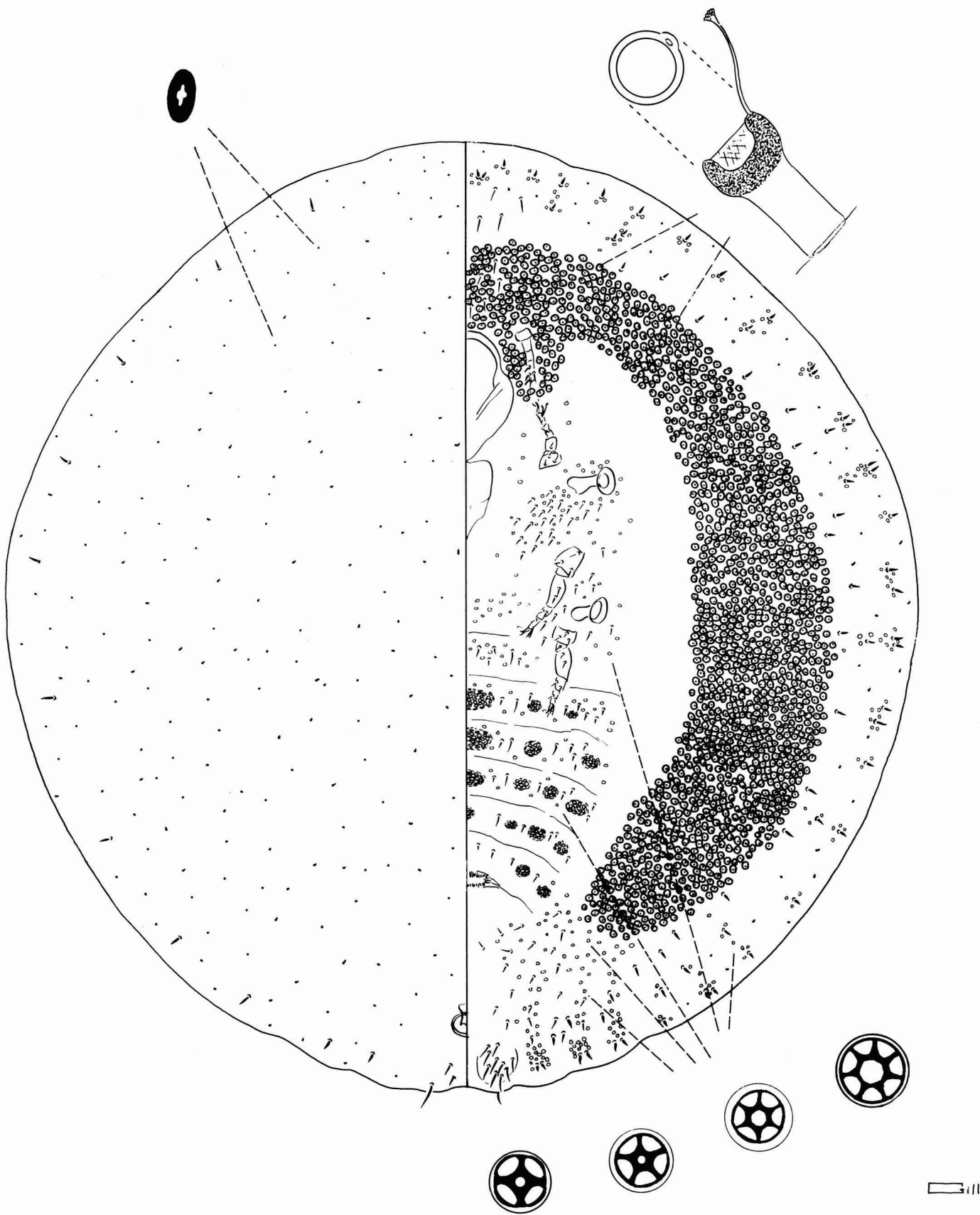


Fig. 75: *Kermes rimarum* Ferris.

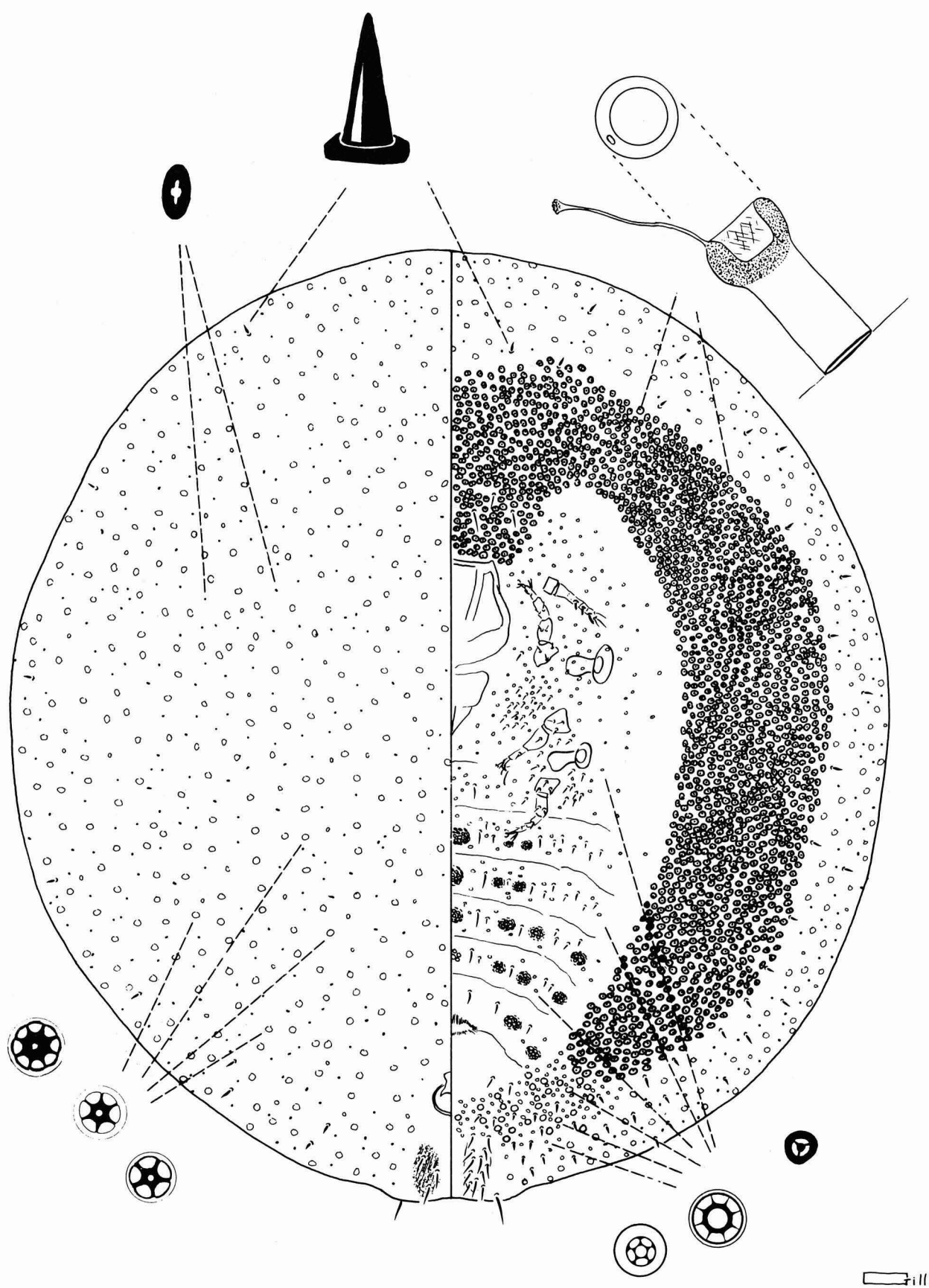


Fig. 76: *Kermes shastensis* Ehrhorn.

FAMILY DACTYLOPIIDAE

cochineal scales

Color Plate 75-79

This small family of scale insects now contains only one genus, *Dactylopius*. The family had at one time included a number of genera (Ferris, 1955) which have since been transferred to the Eriococcidae and Kermesidae. Nine species occur worldwide; three species are known from California. All are cactus feeders. The name *Dactylopius* was applied incorrectly to many species of mealybugs by early authors.

The cochineal scales have played a fascinating role in the history of the Western World. One species of cochineal, *Dactylopius coccus* Costa, was used by the Aztec Indians as a source of a high quality carmine dye. The cultivation and manufacture of this dye was continued and further developed by the Spaniards after the conquest. As much as 7 million pounds of cochineal were produced in 1876. In the meantime, various attempts by individuals of other nations to establish cultures of the cochineal scales had been failures, but not before the cactus hosts of the cochineal had become established in South Africa, Hawaii, Australia, Ceylon, and other parts of the world. The cactus became a serious weed pest problem, and ironically, cochineal scales have since been used with some success as a bio-control agent for these cactus weed pests. For more information on the history of cochineal scales and cochineal production, see Baranyovits (1978), Guerra & Kosztarab (1992), Hunter et al (1912), Mann (1969), Goeden et al. (1967), Karny (1972), Marin & Cisneros (1977), Metcalf & Flint (1939) and Vietmeyer (1987).

Field Characteristics: Adult females 2.0 to 5.0 mm long. Color of all stages bright red (carmine), although often bodies of all female stages except the crawler are completely encased in a protective layer of white, sticky, filamentous wax. Red body normally not visible unless the derm of the insect is punctured, at which time the wax cover and surrounding areas become stained. Apparently young adult females of *Dactylopius tomentosus* are not completely encased in the wax cover, but produce long straight rays of filamentous wax which do not clump together and obscure the body.

Biology: The bionomics of several of the species have been studied under laboratory conditions. A detailed study of the biology of *D. coccus* can be found in Guerra & Kosztarab (1992). However, little is known about the life histories of the California species except for *D. opuntiae*. Apparently all species have multiple yearly generations. For more information see Goeden et al. (1967), Mann (1969), Moran & Cobby (1979), and Gilreath & Smith (1987), .

Similar Species: Cactus spine scale (*Acanthococcus coccineus*) and another eriococcin, *A. dubius*, are similar in that they form white ovisacs on cactus which resemble the white covers of *Dactylopius*. Several mealybugs are also similar. The cactus mealybug *Spilococcus mamillariae* (Bouché) forms white ovisacs on cactus, but the body fluid color is grey rather than bright red. The spinose mealybug (*Hypogeococcus spinosus* Ferris) is very similar to *Dactylopius*, and even has a reddish body, but it is not as bright red and is seldom encountered in the state outside of nursery situations.

Hosts: Restricted to cacti; usually found only on *Opuntia* and *Nopalea*.

Economic Importance: One species of cochineal, *D. coccus* Costa, was cultivated for dye by Spaniards in Mexico, South America, and the Canary Islands. The cochineal industry was lucrative for several hundred years and peaked around 1876. For a time, the anniline dyes had

made cochineal production nearly unfeasible, although a small industry still exists in the Canary Islands, Peru and Mexico. However, recent findings that some of the synthetic red dyes may have cancer-inducing properties has resulted in renewed interest in cochineal. A very thorough treatise on the history and ethnogeographical aspects of cochineal can be found in the work by Donkin (1977). For other information, see Hunter et al (1912), Mann (1969), Ross (1986) and Vietmeyer (1987).

Some species of cochineal scale have been used successfully to control unwanted stands of prickly pear cactus in various parts of the world. A notable example has been the use of *D. opuntiae* on Santa Cruz Island off the coast of southern California (see Goeden et al., 1967 and Goeden & Ricker, 1980). For more information on biological control of cactus, see Goeden et al. (1967), Mann (1969), Karny (1972), Moran & Annecke (1979) and Anonymous (1988). In California, *D. opuntiae* has been known to require treatment on commercially planted *Opuntia* cactus grown for edible cactus fruit. Similarly, it is recorded by Annecke et al. (1976) and Martin & Cobby (1979) as a pest of domesticated cacti used for fodder and fruit in South Africa.

Distribution: Native to and originally restricted to the Western Hemisphere, but cultures have been transported to many parts of the world. All three California species are usually found in the wild in southern and southeastern California, but they are being moved around the state on nursery stock and other container-grown cacti. Specimens may now be found as far north as Del Norte County in nurseries and possibly in wild stands of *opuntia*. The three species are also found in the southwestern United States and northwestern Mexico.

Diagnosis: The genus has been revised by DeLotto (1974) and later thoroughly studied by Guerra & Kosztarab (1992). Any names used or identifications made prior to DeLotto's work must be questioned since the genus was formerly poorly understood taxonomically. The three California species are very similar, but can be separated by the included key.

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Morphological Key to California Dactylopiidae
(based on adult females)

- 1. Dorsal truncated setae essentially as large on the head as on abdomen **opuntiae**
—Dorsal truncated setae much smaller and thinner on the head than on abdomen **2**
- 2. Anal ring completely unsclerotized; with 2 or 3 dorsal rows of truncate setae which are much larger than the rest of the dorsal setae **tomentosus**
—Anal ring sclerotized anteriorly, half-moon shaped; without rows of unusually large dorsal setae **confusus**

CALIFORNIA SPECIES OF DACTYLOPIIDAE
Genus *Dactylopius* Costa, 1835

Dactylopius confusus (Cockerell), 1893
California cochineal scale

Fig. 77, Color Plate 75, 76

Other Common Names:
prickly pear cochineal, cottony cochineal scale.

Synonymy:
Acanthococcus confusus Cockerell, *Coccus confusus* (Cockerell), *Coccus cacti confusus* (Cockerell), *Coccus tomentosus newsteadi* Cockerell, *Coccus tomentosus confusus* (Cockerell), *Pseudococcus confusus* (Cockerell), *Coccus confusus capensis* Green, *Dactylopius greenii* Cockerell, *Dactylopius newsteadi* (Cockerell).

Field Characteristics: Very similar to *Dactylopius opuntiae* but the females are imbedded in such a profuse white wax secretion that it is impossible to distinguish one individual from another.

Biology: Has multiple yearly generations. The bionomics of the species have been worked out by Gilreath & Smith (1987).

Hosts: Prefers the flat-padded *Platyopuntia* cacti.

Economic Importance: None.

Distribution: Southern California and the San Joaquin Valley. Especially common on beavertail cactus in Inyo and Mono Counties. Found as far north as Del Norte County on cactus nursery stock. Also known from Arizona, New Mexico, Texas, and Mexico. According to Gilreath & Smith (1987), it is the most wide spread *Dactylopius* in North America.

Diagnosis: Very similar to *Dactylopius tomentosus*. See the morphological key provided.

Gilreath, M. E. and J. W. Smith Jr., 1987: Ann. Entomol. Soc. Amer. 80(6):765-774.
Mann, J., 1969: U.S. Nat. Mus. Bull. 256:1-158.

Dactylopius opuntiae (Cockerell), 1896
opuntia cochineal scale

Fig. 78, Color Plate 77

Other Common Names:

monacantha cochineal, prickly pear cochineal.

Synonymy:

Coccus cacti opuntiae Cockerell, *Dactylopius tomentosus* Cockerell (misidentification), *Dactylopius indicus* Green (misidentification).

Field Characteristics: Usually occurs in groups about the spine bases, although the white secreted covers of each female are separate.

Biology: According to Mann (1969), can have up to five yearly generations.

Hosts: Prefers the *Platyopuntia* group of flat-pad cacti in the genus *Opuntia*.

Economic Importance: Used successfully for cactus control in Australia, South Africa, and especially on Santa Cruz Island. Goeden & Ricker (1980) state that the Santa Cruz Island population probably originated in Mexico,

but was actually obtained from Australia. Has required treatment on commercial cactus grown for edible cactus apples in California.

Distribution: Widespread in San Diego County and other parts of southern California, but usually uncommon due to natural enemies. Occasionally found in the southern San Joaquin Valley and as far north as Salinas along the coast. Common on Santa Cruz Island, Santa Barbara County; also known from Arizona, New Mexico, Texas, and Mexico.

Diagnosis: Recognized because the setae on the head are about the same size as those on the abdomen. See the morphological key provided.

Goeden, R. D. and D. W. Ricker, 1980: Proc. V, Int'l. Symp. Biol. Contr. Weeds. Brisbane, Australia. pp. 355-365.

Mann, J., 1969: U.S. Nat. Mus. Bull. 256:1-158.

Dactylopius tomentosus (Lamarck), 1801
tomentose cochineal scale

Fig. 79, Color Plate 78, 79

Other Common Names:

Devil's rope pear cochineal.

Synonymy:

Coccus silvestris Lancry, *Acanthococcus tomentosus* (Lamarck), *Coccus tomentosus newsteadi* (Lamarck) in part, *Pseudococcus tomentosus* (Lamarck).

Field Characteristics: Does not produce the extensive white wax covering as do the other species, but instead produces a covering of more transparent, straight wax filaments. Body of adult is visible through these wax filaments.

Biology: Unknown.

Hosts: Prefers *Cylindropuntia* or "cylindrical-

pad" cacti such as cholla.

Economic Importance: None.

Distribution: Southern California, Arizona, Texas, New Mexico, Mexico. Introduced into the Sacramento Valley on cactus nursery stock.

Diagnosis: Field characteristics, the cylindrical-padded host, and the morphological characters given in the key aid in separating this species.

Ferris, G. F., 1955: Atlas of the Scale Insects of North America. Vol. 7. Stanford Univ. Press, Stanford. 233 pp.

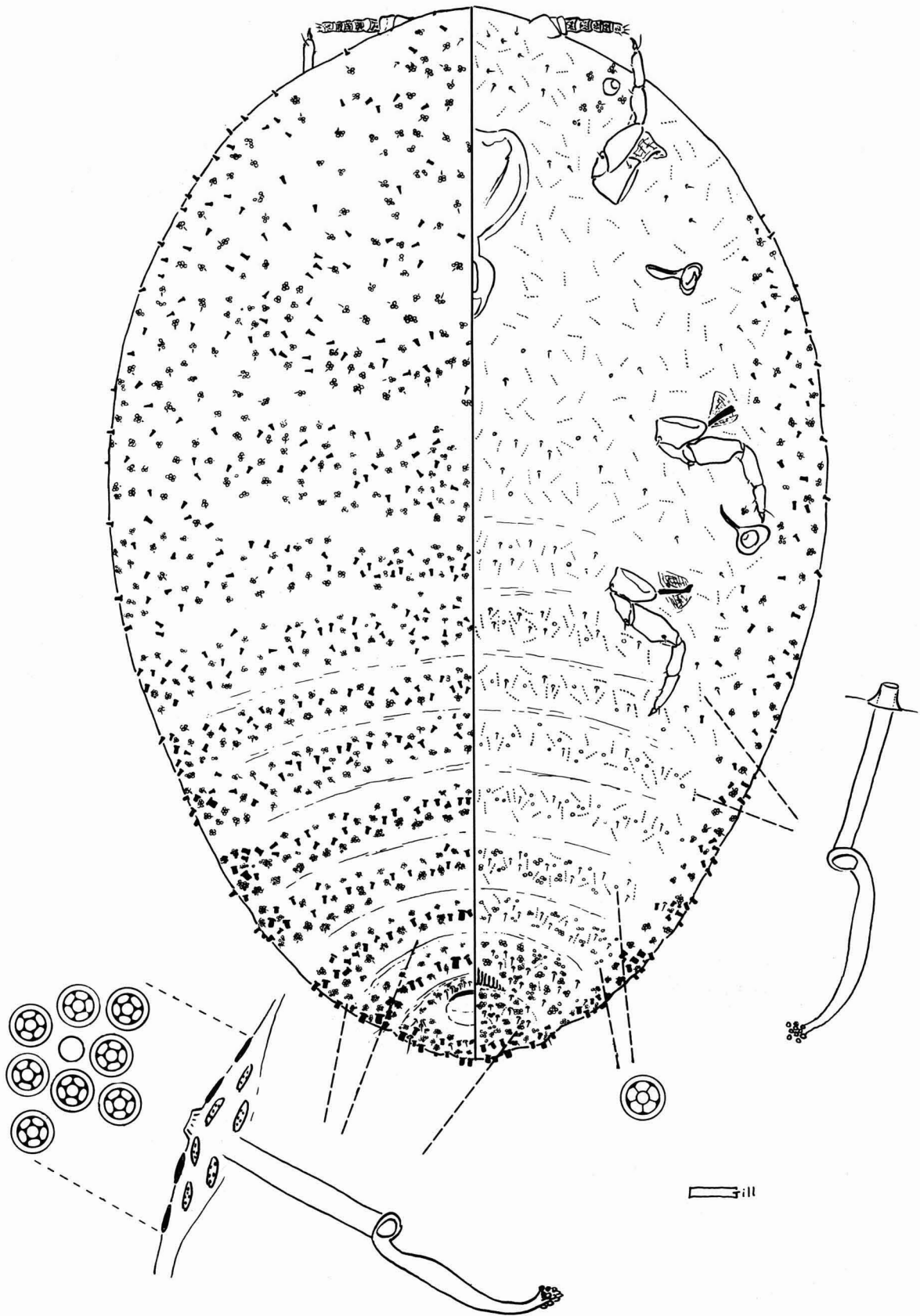


Fig. 77: *Dactylopius confusus* (Cockerell).

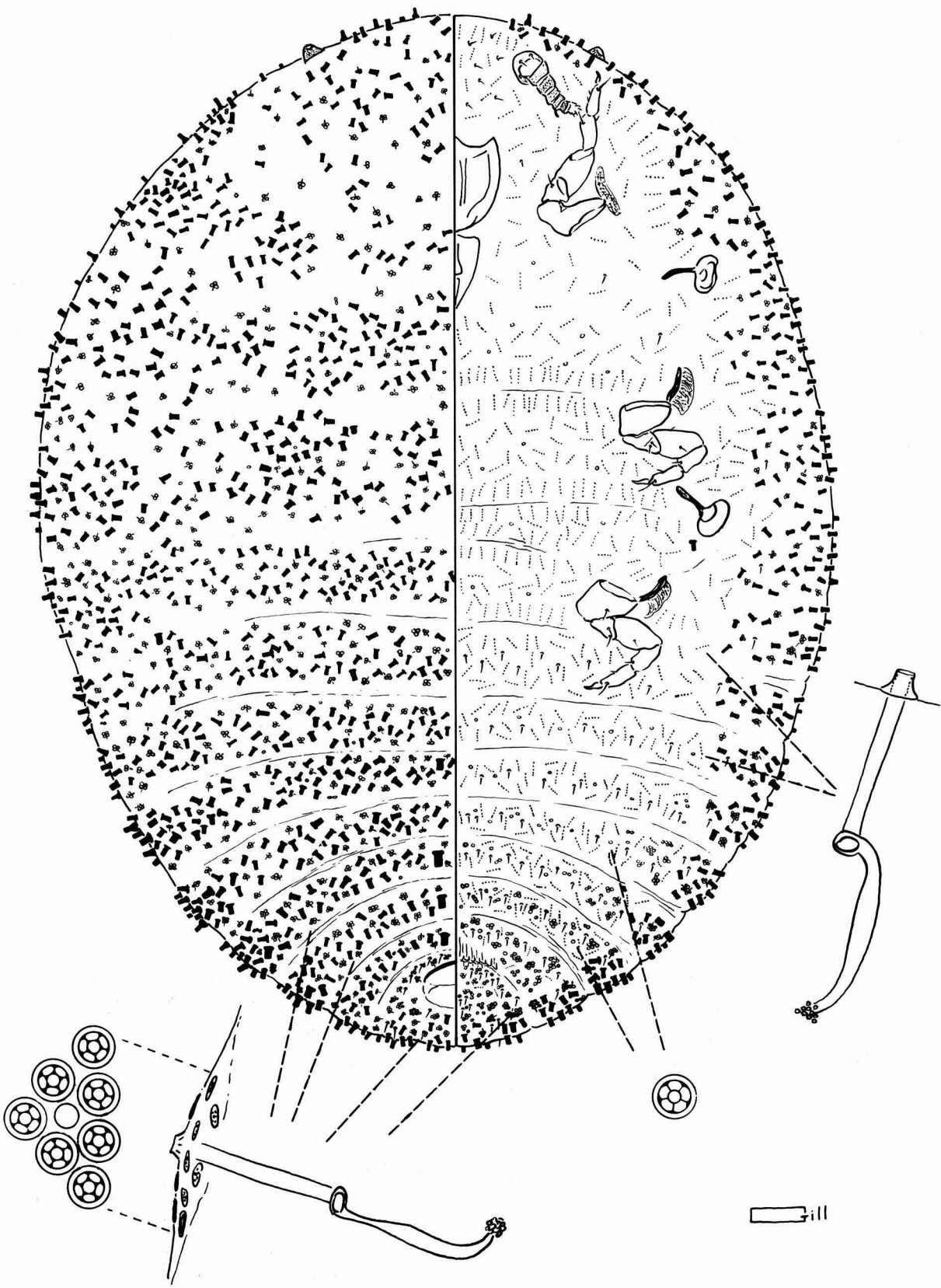


Fig. 78: *Dactylopius opuntiae* (Cockerell).

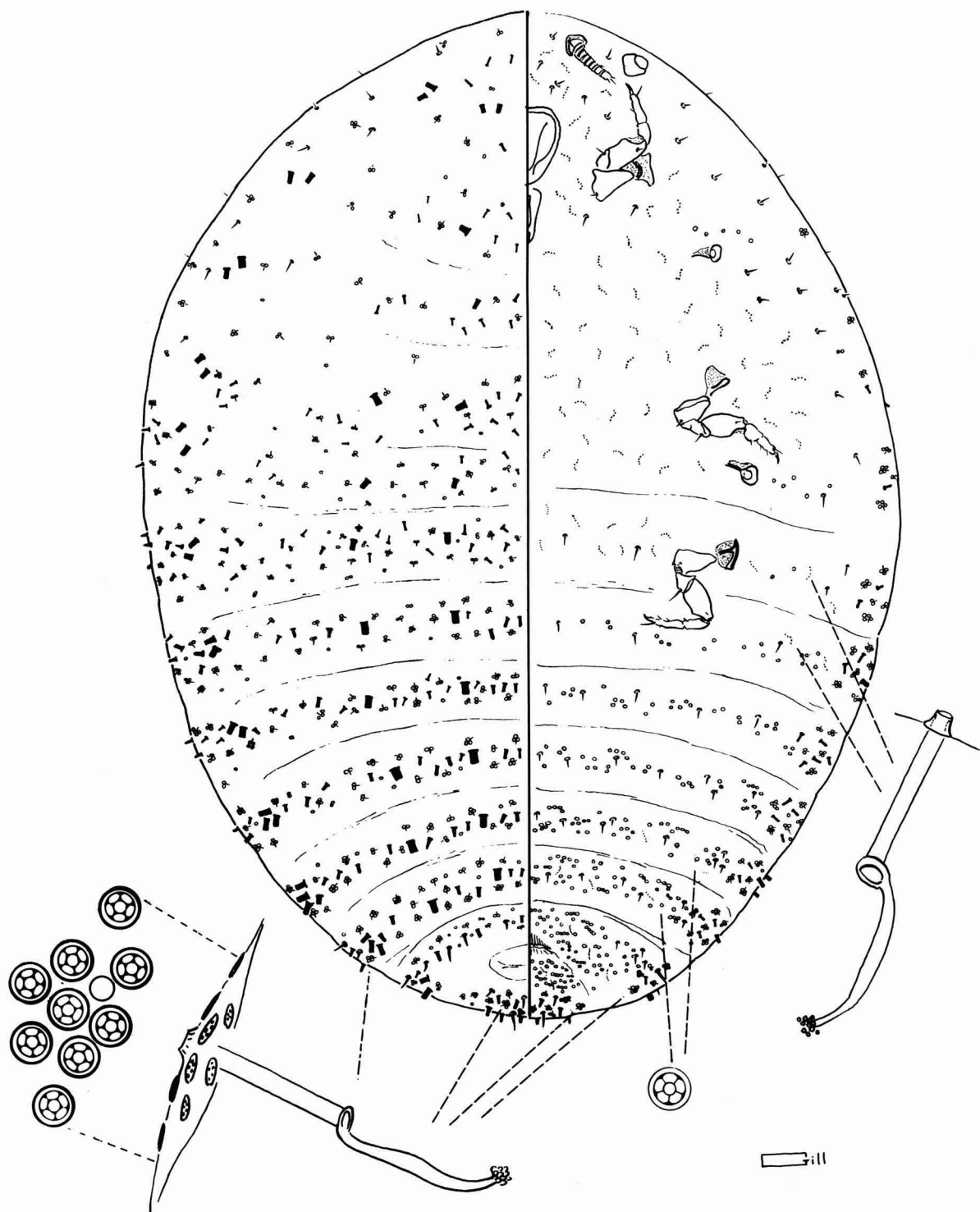


Fig. 79: *Dactylopius tomentosus* (Lamarck).

FAMILY ERIOCOCCIDAE

eriococcins, ovaticoccins, woolly-sac scales, or felt scales

Color Plates 80-107

This interesting group of scale insects contains about 50 genera and 350 species worldwide. Some of the genera considered as Eriococcidae by Ferris (1955), Hoy (1963), and Miller & McKenzie (1967), including *Apiomorpha*, *Beesonina*, *Cryptococcus*, *Dactylopius*, *Kermes*, and *Ollifiella*, have since been placed in other families. Currently there are 11 North American genera including seven in California. The name woolly-sac scale has been used frequently as a common name for this group and refers to the distinctive white ovisacs. The common names eriococcin and ovaticoccin are based on the general morphological characteristics of the United States species and their associated generic relationships (the *Acanthococcus*, *Eriococcus*, *Gossyparia* group and the *Oregmomyza*, *Ovaticoccus* group). In other words, these two names divide the family into two major morphological groupings of species which occur in the United States, although the name eriococcin can refer to the family as a whole.

Field Characteristics: Adults are small to moderate in size (1 to 3 mm long), oval or oblong, and in one genus, *Acanthococcus*, strongly tapered posteriorly. Adults or early stages are usually not covered by mealy wax as are the mealybugs, but they otherwise resemble them closely. In the genera *Acanthococcus* and *Eriococcus*, all female stages possess enlarged spine-like setae which are the internal support for large tapered spines of translucent wax that are visible on the margins and usually on the dorsum of the insects. Species in other genera may or may not have these enlarged dorsal setae, but if they do, the setae are much broader and shorter and do not support long wax spines. The bodies of eriococcins are usually dark brown, pink, or red. The forms which inhabit bark, twigs, and other exposed aerial parts of the host are usually brown and without wax secretions, except for around the dorsal enlarged setae, until the ovisacs are formed. The forms which inhabit deep bark cracks, crowns, roots, and other nonexposed parts of the plant are usually pink or red in color and are often surrounded by amorphous white wax secretions. All forms are well hidden on the host or are otherwise cryptic and difficult to detect, except for matured individuals of the genus *Acanthococcus* which form the white tapered ovisacs and white male puparia on exposed parts of the host. Species in the ovaticoccin groups such as *Ovaticoccus* and *Oregmomyza* are seldom found on the more exposed parts of the host, but are usually found in very deep bark cracks, under bark, deep within crevices in the crowns of the host, or on the roots. Very often the host must be dug up and literally torn apart before the scales can be located. The woolly-sac scales cannot be field identified as a general rule, except for several of the common introduced species like European elm scale and araucaria scale. Host plant preference may be of some aid in narrowing down the number of possible species involved, but host ranges for many of the native California species are not that well known and they are not totally reliable as a field identification aid.

Biology: Very little is known about the biology of the eriococcins, at least in North America, partly because the species are usually so well hidden or are so rare that they are seldom collected. Many of the species probably have only one generation per year, and their life cycle is geared to the growth cycle of the host. There are generally four female instars and five male instars.

Similar Species: The mealybugs are very similar to the woolly-sac scales in appearance and habits, although the body color is normally different between the two and the mealy wax

characteristic of the mealybugs is usually missing in the Eriococcidae.

Hosts: The eriococcins as a whole are not generally restricted to any particular group of hosts, although each individual species seems to be host specific. Among the native California forms, plants in the families Chenopodiaceae and Compositae seem to be preferred by the majority of species.

Economic Importance: Only a few of the Eriococcidae are pests of any significance, and these usually are not pests of food or fiber plants which might be considered important to mankind. Those species that are pests are normally pests of ornamental plants and nursery stock. A few species are minor pests of the eucalyptus timber industry in Australia and New Zealand and one species, *Acanthococcus insignis*, is a pest of grasses.

Distribution: The family as a whole is practically worldwide in distribution with species native to most continents except for most of southern Africa. It may have originated in and developed outward from the Antarctic region which at one time included parts of New Zealand and the southern tip of South America. Some interesting theories on this matter have been proposed by Hoy (1962) and studied, if not substantiated, in part by Miller & Gonzalez (1975).

Diagnosis: This family is difficult to define completely, and the diversity of its morphological characteristics has resulted in the placement here of several forms which are now included in other families. The family is best recognized by:

- a. the presence of well-developed legs in most species,
- b. macrotubular ducts common and with a cup-shaped sclerotized internal end,
- c. cruciform pores usually present,
- d. anal lobes often present and well developed,
- e. antennae usually 5- to 7-segmented,
- f. ostioles, cerarii, circuli and pseudococcin-type trilocular pores all absent,
- g. microtubular ducts characteristic,
- h. leg seta arrangement distinctive compared with Pseudococcidae.

For a key to the North American genera and to the North American species of the ovaticoccin group, see Miller & McKenzie (1967). The species of North American *Acanthococcus* can be keyed in Ferris (1955), although the species are in the genus *Eriococcus*, the morphology of some of the species is variable and a number of species have since been described, thus reducing the reliability of the key. A key to the genera of the Eriococcidae and to the species of *Acanthococcus* of the eastern United States can be found in Miller & Miller (1993). Keys to the species of western Eriococcidae and *Acanthococcus* and following keys to the species of California Eriococcidae are based on Miller & McKenzie (1967) and Miller & Miller (1992).

References:

- Ferris, G. F., 1955: Atlas of the Scale Insects of North America. Vol. 7. Stanford Univ. Press, Stanford. 233 pp.
- Hoy, J. M., 1962: N.Z. Dep. Sci. Ind. Res. Bull. 146:1-219.
- Hoy, J. M., 1963: N.Z. Dep. Sci. Ind. Res. Bull. 150:1-260.
- Miller, D. R. and R. H. Gonzalez, 1975: Rev. Chil. Entomol. 9:131-163.
- Miller, D. R. and H. L. McKenzie, 1967: Hilgardia 38(13):471-539.
- Miller, D. R., 1991: Proc. Entomol. Soc. Wash. 93(2):333-355.
- Miller, D. R. and G.L. Miller, 1992: Trans. Amer. Entomol. Soc. 118(1):1-106.
- Miller, D. R. and G.L. Miller, 1993: Contr. Amer. Entomol. Inst. 27(4):1-91.

KEY TO THE CALIFORNIA GENERA OF ERIOCOCCIDAE

- 1. Macrotubular ducts in large clusters on ventral abdominal margins *Cornoculus*
— Not as above 2
- 2. Anal lobes present, usually elongate in *Acanthococcus*, but may appear as low protrusions in other genera, giving the posterior margin a shallow but definite indentation 3
— Anal lobes not indicated, posterior margin of abdomen uniformly rounded . *Ovaticoccus*
- 3. Quinquelocular pores present in spiracular atrium *Spiroporococcus*
— Not as above 4
- 4. Dorsal quinquelocular pores present 6
— Dorsal quinquelocular pores absent 5
- 5. Macrotubular ducts absent in central areas of dorsum *Gossyparia*
— Dorsal macrotubular ducts evenly scattered over most of dorsum *Acanthococcus*
- 6. Anal lobes sclerotized, apically pointed, strongly produced *Atriplicia*
— Anal lobes unsclerotized, rounded *Oregmomyga*

THE CALIFORNIA SPECIES OF ERIOCOCCIDAE

Genus *Acanthococcus* Signoret, 1875

This is the largest genus of the Eriococcidae in the United States, containing about 40 species. The genus contains species which are very similar in appearance, morphology and habit to the genus *Eriococcus*, which comprises a large number of species in Europe and Australia. However close the similarities, they were separated by Miller (1991) because *Acanthococcus* lacks certain distinctive enlarged tubular ducts found in *Eriococcus buxi*, the type species of that genus. The genus is not fully understood in the United States, partly because some of the species tend to be variable morphologically and it is difficult to define species limits. Also, most native United States species of *Acanthococcus* are seldom collected because of their secretive habits; if they were collected more frequently, the students of the genus might have a much better understanding of the group. The genus is recognized morphologically by the presence of cruciform pores; distinct, well-developed anal lobes; well-developed anal ring; and enlarged, conical dorsal and/or lateral setae (spines); absence of discoidal pores; and distinctive microtubular ducts. For a comprehensive bibliography, host list and list of world species, see Hoy (1963). Miller (1969) has studied the species in western North America and included his findings in an unpublished Doctoral dissertation. More recently Miller (1991) and Miller & Miller (1992) have described numerous new species from the southwestern part of the United States, and redescribed most of the others from this area. Species characteristics listed under "Diagnosis" and the following key are taken in part from these recent works. It is probable that a number of the species recently described from the southwest also occur at least in the Great Basin areas of California, such as *A. arenosus*, which is recorded in Washoe County, Nevada, on the California border.

References

- Hoy, J. M., 1963: N.Z. Dep. Sci. Ind. Res. Bull. 150:1-260.
 Miller, D. R., 1969: A Systematic Study of *Eriococcus* Targioni-Tozzetti of the Western United States. Unpubl. Doctoral Thesis, Univ. Calif., Davis.
 Miller, D. R., 1991: Proc. Entomol. Soc. Wash. 93(2):333-355.
 Miller, D. R. and G.L. Miller, 1992: Trans. Amer. Entomol. Soc. 118(1):1-106.

Key to the California species of *Acanthococcus*

1. With 4 or fewer setae on each hind tibia (NOTE: illustrations show setae only on ventral side of tibiae, however, total number on both sides is critical) **2**
 — With 5 or more setae on each hind tibia **14**
- 2(1). Dorsal multilocular pores present *palustrus*
 — Dorsal multilocular pores absent **3**
- 3(2). Anal lobes heavily sclerotized dorsally (Figs. 81 and 100); microtubular ducts bifurcate **4**
 — Anal lobes unsclerotized or lightly sclerotized dorsally (Figs. 80 and 87); microtubular ducts simple **6**
- 4(3). Lateral enlarged setae over three times longer than dorsomedial setae; dorsomedial setae with blunt apices *araucariae*
 — Lateral enlarged setae equal in length to at least some dorsomedial setae; dorsomedial setae with acute or rounded apices **4**
- 5(4). With 4 or 5 setae on each tibia; hind coxae with pores absent; dorsal enlarged setae slender (Fig. 83) "*Eriococcus*" *borealis* and *A. azaleae*
 — With 2 setae on each tibia; hind coxae with many pores ventrally; dorsal enlarged setae with broad bases (Fig. 100) *pittospori*
- 6(3). Lateral enlarged setae approximately equal in length to largest dorsomedial setae . **7**
 — Lateral enlarged setae at least twice as long as largest dorsomedial setae **12**
- 7(6). Anal lobes with 4 enlarged setae *froebeae*
 — Anal lobes with 3 enlarged setae **8**
- 8(7). Lateral enlarged setae strongly curved; legs unusually large (Figs. 96) *larreae* (in part)
 — Lateral enlarged setae straight or slightly curved; legs of normal size (Figs. 89 and 97) . **9**
- 9(8). Anal ring with 3 pairs of setae *mackenziei*
 — Anal ring with 4 pairs of setae **10**
- 10(9). Largest lateral seta on each abdominal segment with acute apex (Fig. 89); largest setae forming three pairs of longitudinal lines (lateral, sublateral, medial) . . . *dubius* (in part)
 — Largest lateral seta on each abdominal segment with rounded or blunt apex (Figs. 80 and 104); large setae showing no longitudinal pattern **11**

- 11(10). Hind coxae with large, indistinct pores (Fig. 80); cruciform pores normally absent *adenostomae*
— Hind coxae with small distinct pores (Fig. 104); cruciform pores abundant *tinsleyi*
- 12(6). Abdominal quinquelocular pores more numerous than all other multilocular pores combined; front tibiae with 4 setae *larreae* (in part)
— Abdominal quinquelocular pores less numerous than all other multilocular pores combined; front tibiae with 5 setae 13
- 13(12). With 3 enlarged setae on each anal lobe; discoidal pores lacking; with microtubular ducts *smithi*
— With 4 enlarged setae on each anal lobe; discoidal pores present; microtubular ducts lacking (Now included in the Kermesidae) "*Eriococcus*" *gillettei*
- 14(1). Dorsal enlarged setae fusiform *salaris*
— Dorsal enlarged setae not fusiform 15
- 15(14). Abdominal quinquelocular pores less numerous than all other multilocular pores combined 16
— Abdominal quinquelocular pores more numerous than all other multilocular pores combined 17
- 16(15). Front tibiae each with 6 setae; not on grass (Poaceae) *texanus*
— Front tibiae each with 5 setae; occurring on grass *insignis*
- 17(16). Tibia at least one and one-half times longer than tarsus *quercus*
— Tibia slightly longer or shorter than tarsus 18
- 18(17). Largest lateral seta on abdomen 3 times longest medial or sublateral seta; lateral abdominal setae forming conspicuous marginal band around shorter medial and sublateral setae 19
— Largest lateral seta on abdomen less than 2 times longer than longest medial or sublateral seta; lateral abdominal enlarged setae not forming conspicuous marginal band as above 22
- 19(18). With 1 large seta on margin of each abdominal segment *cryptus*
— With 2 or more large setae on margin of each abdominal segment 20
- 20(19). Body elongate; with 2 large setae on margin of each abdominal segment; occurring only on grasses (Poaceae) *hoyi* (in part)
— Body oval; with 3 or more enlarged setae on marginals of abdominal segments; not on grasses 21
- 21(20). Enlarged setae on medial and sublateral areas of abdomen truncate apically (Fig. 86); on cactus *coccineus*
— Enlarged setae on medial and sublateral areas of abdomen rounded apically (Fig. 92); not on cactus *euphorbiae* (in part)

- 22(18). Anal lobes with 4 enlarged setae *macrobactrus*
 — Anal lobes with 3 enlarged setae 23
- 23(22). Large sized dorsal setae apically acute 24
 — Large sized dorsal setae apically rounded or truncate 26
- 24(23). Anal ring with 3 pairs of setae; occurring on *Artemisia* *epacrotrichus*
 — Anal lobes with 4 enlarged setae 25
- 25(24). Body elongate (Fig. 88); microtubular ducts short (4.0 to 5.0 μ long); occurring on grass (Poaceae) *diaboli*
 — Body oval (Figs. 87, 89, and 91); microtubular ducts moderate in length (5.0 to 8.0 μ long); not on grass *dubius* (in part)
- 26(23). Dorsal body setae characteristically broad, short, apically rounded *barri*
 — Dorsal body setae not as above 27
- 27(26). Body elongate, enlarged setae in reduced numbers on medial and lateral areas of body; on grasses (Poaceae) *hoyi* (in part)
 — Body oval, enlarged setae numerous over dorsum; not on grasses 28
- 28(27). With 1 pair of longitudinal lines of large setae (lateral), 3 pairs of lines rarely present on posterior four abdominal segments *erigoni*
 — With 3 pairs of longitudinal lines of large setae (medial, sublateral, lateral), present from posterior abdominal segments through thorax 29
- 29(28). Largest lateral setae on abdominal segments VIII and VII apically blunt or truncate *arctostaphyli*
 — Largest lateral setae on abdominal segments VIII and VII apically rounded 30
- 30(29). With more than 30 enlarged setae on abdominal segment V; frequently with 6 setae on front tibiae *dubius* (in part)
 — With 30 or fewer enlarged setae on abdominal segment V; with 5 setae on front tibiae *euphorbiae* (in part)

Acanthococcus adenostomae (Ehrhorn), 1898
 chamise eriococcin

Fig. 80, Color Plate 80

Synonymy:

Eriococcus adenostomae Ehrhorn, *Nidularia adenostomae* (Ehrhorn).

Field Characteristics: Adult females purple; ovisac white or yellowish-white. Commonly found on the aerial parts of the host including branches and small twigs.

Hosts: Chamise (*Adenostoma fasciculatum*).

Distribution: Generally distributed in chaparral areas of the state.

Economic Importance: None.

Diagnosis: Host preference is one of the best ways of identifying this species. However, it is morphologically separated from other Cali-

for *Acanthococcus* by the following characteristics: four setae on the hind tibiae; straight or slightly curved dorsal enlarged setae ap-

proximately the same size as the marginal enlarged setae; lack of cruciform pores; large indistinct pores on the hind coxae.

***Acanthococcus araucariae* (Maskell), 1879**
Norfolk Island pine eriococcin

Fig. 81, Color Plate 81, 82

Other Common Names:

felted pine coccid, araucaria eriococcin.

Synonymy:

Eriococcus araucariae Maskell, *Uhleria araucariae* (Maskell), *Rhizococcus araucariae* (Maskell), *Criococcus araucariae* (Maskell), *Nidularia araucariae* (Maskell).

Field Characteristics: Adult females 1.5 to 3.0 mm long, elongate oval (posteriorly tapered), yellowish-brown with a pair of purplish stripes on the sublateral margins of the abdomen (actually this appears to be a broad longitudinal mid-dorsal light-colored stripe). The margins bear transparent brownish waxen spines; the dorsal waxen spines commonly found in most other California *Acanthococcus* are missing. Ovisac typical of the *Acanthococcus* group, white and posteriorly tapered. Usually found on stems at bases of leaflets or on leaflets themselves.

Biology: Unknown, although collection data indicate at least two yearly generations. Males active in August.

Similar Species: Most *Acanthococcus* scales are similar, particularly in the ovisac stage. Host preference is the best criterion for field recognition.

Hosts: Primarily Norfolk Island or star pines

(*Araucaria excelsa*). Also known from other species of *Araucaria*.

Economic Importance: Occasionally a pest of ornamental *Araucaria* in other parts of the world; not generally a pest in California. Populations apparently are effectively checked by *Cryptolemus* ladybird beetles and other natural enemies. A honeydew producer; this plus the white ovisacs produced may act together to give the host an unsightly appearance. For more information, see Zimmerman (1948).

Distribution: Coastal southern California and the San Francisco Bay region. Probably most common in San Diego County. Apparently native to Australia, but has been introduced into many of the tropical and subtropical areas of the world.

Diagnosis: Host preference is a primary recognition characteristic. Also has the following morphological characteristics: four setae on the hind tibiae; dorsally sclerotized anal lobes; lateral enlarged setae conical and much larger than the dorsal enlarged setae which are short and truncate.

Zimmerman, E.C., 1948: Insects of Hawaii, Vol. 5, Homoptera: Sternorhyncha, Univ. Hawaii Press, Honolulu. 464 pp.

***Acanthococcus arctostaphyli* (Ferris), 1955**
manzanita eriococcin

Fig. 82.

Synonymy:

Eriococcus arctostaphyli Ferris.

Hosts: Manzanita.

Distribution: San Bernardino and Shasta

Counties.

Economic Importance: None; very rare.

Diagnosis: Host plant restriction will aid in recognition. Very similar morphologically to

a number of other species, although the following characteristics serve to distinguish it: five setae on the hind tibiae; three enlarged anal lobe setae; enlarged marginal setae somewhat larger than most dorsal setae, except for

three (2 submarginal, 1 medial) longitudinal rows of somewhat bigger dorsal enlarged setae; marginal abdominal enlarged setae rounded or truncate at apices.

Acanthococcus azaleae (Comstock), 1881
azalea bark scale (ESA approved)

Fig. 83, Color Plate 83, 84

Synonymy:

Eriococcus azaleae (Comstock), *Nidularia azaleae* (Comstock).

Field Characteristics: Adult females 1.0 to 3.5 mm long, elongate oval (posteriorly tapered), purplish to brownish. Each individual is covered with tan or brown clear waxy spines which resemble the pubescent areas of the stems and leaves of the host. A pure white, tapered ovisac is formed on the twigs and branches of the host.

Biology: Normally found on twigs, although nymphs may feed for a time on leaves. Usually one generation per year in colder climates, with older nymphs and adults overwintering. Ovisacs formed and eggs laid in spring. Two generations per year are recorded in Alabama. The above biological information summarized from English & Turnipseed (1940), Schread (1954, 1961), and Stimmel (1982).

Similar Species: Identical in the field to many other species of *Acanthococcus*. Therefore, host preference is the only criterion that can be used in field identification.

Hosts: Prefers azalea and rhododendron, although it is an occasional pest of cranberries (*Vaccinium*) in the eastern United States. For a host list, see Merrill (1953) and Schread (1961).

Economic Importance: Can be a troublesome pest of azaleas and rhododendrons. Injury consists of unsightly honeydew and sooty mold on the plants, roughened and malformed branches, stunting, dieback, and occasionally the death of small plants. Not presently a pest in California, because it is eradicated when-

ever it is found. Currently a "B"-rated pest. The above economic information summarized in part from English & Turnipseed (1940), Weigel & Baumhofer (1948), Schread (1954, 1961), and Tomlinson (1957).

Distribution: Found occasionally in nurseries throughout the state for many years, as recently as 1983. Present status in the state unknown. Generally distributed in the eastern United States; apparently common in Oregon and Washington. Possibly native to North America.

Diagnosis: Host preferences and the following morphological characteristics will aid in recognition: 4 setae on the hind tibiae; anal lobes dorsally sclerotized and with meso-lateral teeth or knobs; slender, apically-pointed or apically-rounded dorsal enlarged setae. There is some question in the literature (Ferris, 1955) about the status of this species and *A. borealis*. The two species are similar and intergrade in such characteristics as the shape of the dorsal enlarged setae and the presence of the meso-lateral teeth on the anal lobes. This problem is further discussed by Miller & Miller (1992) and, although *A. borealis* is synonymized by them, that concept will not be followed here. For further comment see *A. borealis*.

English, L.L. and G.F. Turnipseed, 1940: Univ. Ala. Agric. Exp. Stn. Circ. 84:1-18.

Ferris, G.F., 1955: Atlas of the Scale Insects of North America. Vol. 7. Stanford Univ. Press, Stanford. 233 pp.

- Merrill, C.B., 1953: Fla. State Plant Board Bull. 1:1-143.
- Miller, D.R. and G.L. Miller, 1992: Trans. Amer. Entomol. Soc. 118(1): 1-106.
- Schread, J. C., 1954: J. Econ. Entomol. 47(3):498-500.
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- Stimmel, J. F., 1982: Pa. Dep. Agric. Reg. Hort. Entomol. Circ. 66. 8(1):17-18.
- Tomlinson, W.E., 1957: J. Econ. Entomol. 50(1):113-114.
- Weigel, C. A. and L. G. Baumhofer, 1948: U.S. Dep. Agric. Misc. Publ. 626:1-115.

Acanthococcus barri Miller, 1991
Barr eriococcin

Fig. 84

Field Characteristics: Adult females white or light yellow and covered with white crystalline rods. The ovisac is white, strongly woven. Usually found on the roots and crown of host.

Hosts: Shad scale, *Atriplex* species.

Distribution: Great Basin habitats in Idaho,

Nevada and probably Utah. Has been recorded from Bishop, Inyo County.

Economic Importance: None.

Diagnosis: Recognized by having the unusual short, broad, blunt dorsal setae. It has five setae on the hind tibiae.

"Eriococcus" borealis Cockerell, 1899
boreal eriococcin

Fig. 85, Color Plate 85, 86

Synonymy:

Eriococcus borealis Cockerell, 1899.

Field Characteristics: Adult females dark purplish-red, covered with sparse transparent crystalline rods; ovisacs white. Occurs on the aerial parts of host, usually on smaller branches some distance from the ground.

Hosts: Prefers willow (*Salix*). Has also been found on *Ribes*, *Populus*, and possibly *Liquidambar*.

Distribution: Generally distributed in the western United States. Common on the west side of the San Joaquin Valley.

Economic Importance: None.

Diagnosis: Preference for willow aids in recognition. Morphologically it is recognized by the following characteristics: four setae on the hind tibiae, anal lobes sclerotized and often with teeth on the mesal edges, and dorsal enlarged setae subequal to lateral enlarged setae in length. This species has characteris-

tics which intergrade with those of *Acanthococcus azaleae*, and it is considered a synonym by Miller and Miller (1992). See comments under *Acanthococcus azaleae*. This synonymy will not be followed here because the habits and physical appearance of *A. borealis* in the field are different than those of *A. azaleae*, and while their morphology intergrades and they are therefore probably very closely related, there is still a chance that specific differences do occur. The color photographs (Plates 83 to 86) indicate the physical differences. The willow-infesting form that is here considered as *A. borealis* usually inhabits remote native watersheds where the host occurs, but the expansion of urbanized areas into these remote habitats in recent years has not produced a population that has moved onto azaleas, the preferred host of *A. azaleae*. In California, the azalea-infesting form (*A. azaleae*) occurs as far as known only on nursery

stock and is generally eradicated whenever found. Probably only detailed biological studies of the two forms can adequately resolve this problem, but until this can be done, it is in

the best interests of the quarantine system of California to continue to consider these two entities as separate species.

***Acanthococcus coccineus* (Cockerell), 1894**
cactus spine scale

Fig. 86, Color Plate 87-88

Other Common Names:

cactus eriococcin, spine mealybug, woolly cactus scale, cactus mealybug.

Synonymy:

Eriococcus coccineus Cockerell, *Eriococcus coccineus lutescens* Cockerell, *Eriococcus cactearum* Leonardi, *Nidularia coccineus* (Cockerell), *Rhizococcus cactearum* (Leonardi).

Field Characteristics: Adult females 1.5 to 3.5 mm long, elongate oval (posteriorly tapered), yellowish-brown to red or purple, depending on age or other factors. Sometimes with a light median stripe. Like *A. araucariae*, it has only marginal waxen spines; dorsal wax spines absent. Ovisac typical of most of the species in the genus except that they are constructed near the apex of the spines of the host. Found on fleshy parts of host except when adult females produce ovisacs on spines.

Biology: Unknown, except that there are apparently continuous overlapping generations.

Similar Species: Host preference should aid in separating this species from most other Eriococcids. *A. eriogoni* and *A. dubius* are

occasionally found on cactus, but they have dorsal waxen spines, which *E. coccineus* lacks. Some of the cactus feeding mealybugs also resemble cactus spine scale, but they have different shaped ovisacs and the mealybugs are covered with mealy white wax.

Economic Importance: A minor pest of cactus nursery stock. Honeydew, sooty mold, and the white ovisacs on the spines cause the plants to be unsightly. Feeding may cause discoloration, weakening, or death of the host.

Distribution: Generally distributed throughout the state on ornamental cacti. Usually not found on native cacti in California. Probably native to the southwestern United States and northwestern Mexico; now cosmopolitan.

Diagnosis: Host plant restriction is a good recognition characteristic. Recognized morphologically by the following characteristics: five setae on the hind tibiae; ventral disc pores primarily with five loculi (quinelocular); length of hind tibiae subequal to hind tarsi; marginal enlarged setae three per abdominal segment and much larger than dorsal enlarged setae; dorsal enlarged setae apically truncate.

***Acanthococcus cryptus* (Cockerell), 1901**
cryptic eriococcin

Fig. 87, Color Plate 89

Synonymy:

Eriococcus cryptus Cockerell, *Eriococcus tinsleyi cryptus* Cockerell, *Nidularia cryptus* Cockerell.

Field Characteristics: Adult females usually dark grey, sometimes becoming more reddish

with maturity. Usually found on the roots and crowns of hosts.

Hosts: Primarily *Gutierrezia* and similar composites.

Distribution: Inyo County, California; Arizona, New Mexico, Kansas, Texas.

Economic Importance: None.

Diagnosis: Characterized by having 5 setae on the hind tibiae, having most of the ventral multilocular pores on the abdomen with 5

loculi, and by having only one lateral enlarged seta on each margin which is two or three times as long as the dorsal enlarged setae.

Acanthococcus diaboli (Ferris), 1955

Mt. Diablo eriococcin

Fig. 88, Color Plate 90, 91

Synonymy:

Eriococcus diaboli Ferris.

Field Characteristics: Body light grey of tan; ovisacs white or tan. Occurs on host leaf blades.

Hosts: Grasses.

Distribution: Contra Costa, Inyo, Los Angeles, Mono, San Benito, and Santa Barbara Counties; southern Oregon.

Economic Importance: None.

Diagnosis: Recognized by host preference and by the following characteristics: 5 setae on the hind tibiae, lateral enlarged setae undifferentiated from and the same size as the dorsal enlarged setae, dorsal enlarged setae with apices acutely pointed, and by the elongated body.

Acanthococcus dubius (Cockerell), 1896

uncertain eriococcin

Fig. 89, Color Plate 92, 93

Synonymy:

Eriococcus dubius Cockerell, *Nidularia dubia* Cockerell, *Eriococcus quercus toumeyii* Cockerell, *Eriococcus toumeyii* (Cockerell), *Nidularia dubius* (Cockerell), *Eriococcus cockerelli* Essig, *Nidularia cockerelli* Essig, *Eriococcus paenulatus* Ferris, *Eriococcus stanfordianus* Ferris, *Nidularia stanfordianus* (Ferris), *Nidularia cockerelli* (Essig), *Nidularia villosula* Lindinger, *Eriococcus villosulus* Ferris, *Eriococcus villosus* Froggatt.

Field Characteristics: Adult females usually dark, ranging from grey or purple to green; ovisac tan. Commonly found on all parts of the host, particularly the crowns and larger branches.

Hosts: Polyphagous.

Distribution: Generally distributed in California and the southwest. Also known from the East Coast of the United States and from Mexico.

Economic Importance: None.

Diagnosis: A variable species; there may be substantial synonymy involved. Best recognized by the following characteristics: usually 5 setae on the hind tibiae; many dorsal enlarged setae equal in size to the lateral enlarged setae; all enlarged setae with apices pointed; and the enlarged setae, particularly the biggest enlarged ones, arranged in lateral, dorso-medial and median rows, at least on the abdomen. The number of enlarged setae can be variable; see the two line illustrations (Figs. 89A & 89B).

Acanthococcus epacrotrichus Miller, 1991
pointed hair eriococcin

Fig. 90, Color Plate 94, 95

Field Characteristics: Body purple, but appearing white because of many crystalline rods and associated dorsal wax. Usually found on aerial portions of host.

Hosts: Restricted to *Artemisia* species, primarily *A. tridentata* and *A. californica*.

Distribution: Widespread from Alpine and Lassen Counties south to Orange and Riverside Counties. Known also from Idaho, Ne-

vada, Oregon, Washington and Baja California, Mexico.

Economic Importance: None.

Diagnosis: Recognized by the large numbers of acute dorsal setae (more than 60 on abdominal segment V), no ventral multilocular pores, five setae on hind tibia, oval body shape, and preference for hosts in *Artemisia*.

Acanthococcus eriogoni (Ehrhorn), 1911
erionum eriococcin

Fig. 91, Color Plate 96, 97

Synonymy:

Eriococcus eriogoni Ehrhorn, *Eriococcus pluchaeae* (Ferris).

Field Characteristics: Adult females grey or green with a reddish tinge on maturity; crystalline rods short, giving specimens a woolly appearance. Have been collected from all parts of host.

Hosts: Polyphagous. Common on *Eriogonum*, *Ephedra*; occasionally found on cactus nursery stock.

Distribution: Southern California, southwestern United States.

Economic Importance: None; may possibly be a minor pest of cactus nursery stock.

Diagnosis: Very similar to *A. dubius*, but the larger enlarged setae are not arranged in longitudinal lines as they are on the abdomen of *dubius*, the dorsal enlarged setae are more rounded apically than in *dubius*, and they are more strongly curved than in *dubius*.

Acanthococcus euphorbiae (Ferris), 1955
euphorbia eriococcin

Fig. 92

Synonymy:

Eriococcus euphorbiae Ferris.

Field Characteristics: Adult females grey or green, overwintering females often red; ovisac white, felted. Occurs on crowns and roots.

Hosts: Polyphagous, but most common on *Euphorbia* and *Eriogonum*.

Distribution: Generally distributed in Cali-

fornia and the western United States.

Economic Importance: None.

Diagnosis: Recognized by having 5 setae on the hind tibiae, lateral enlarged setae much larger than the dorsal enlarged setae, dorsal enlarged setae acute or rounded apically and each abdominal segment margin with 3 large enlarged setae.

Acanthococcus froebeae Miller, 1991
Froebe eriococcin

Fig. 93

Hosts: Foliage of *Atriplex* and *Franseria*.

Distribution: Desert areas of Riverside and San Bernardino Counties.

Economic Importance: None.

Diagnosis: Recognized by having four setae on hind tibiae, four pairs of setae on the anal lobes, and nearly uniform-sized dorsal setae.

Acanthococcus hoyi Miller and Miller, 1992
Hoy eriococcin

Fig. 94

Hosts: Known only from the grass genus *Bouteloua*. Occurs on the leaf blades.

Distribution: The only known California collection is from three miles south of Lancaster, Los Angeles County. Also known from Arizona, Colorado, New Mexico and Texas.

Economic Importance: None.

Diagnosis: Recognized by small sized dorsomedial enlarged setae on each anal lobe, more quinquelocular than septelocular pores, and preference for grass hosts.

Acanthococcus insignis (Newstead), 1891
remarkable eriococcin

Fig. 95

Synonymy:

Eriococcus insignis Newstead, *Eriococcus saratogensis* Rau.

Field Characteristics: Adult females red, ovisac yellowish-white. Occurs on host leaves.

Hosts: Grasses.

Distribution: Del Mar, San Diego County, probably a nursery stock introduction. Known also from Washington, Idaho, and New York.

Apparently introduced from Europe.

Economic Importance: None.

Diagnosis: Host preference and the following characteristics aid in recognition: 5 setae on the hind tibiae, lateral enlarged setae much larger than the dorsal enlarged setae, ventral abdominal multiloculars primarily with more than 5 loculi, and 5 or more enlarged setae on each segmental margin.

Acanthococcus larreae (Parrott & Cockerell), 1899
creosote eriococcin

Fig. 96

Synonymy:

Eriococcus larreae Parrott & Cockerell, *Nidularia larreae* (Parrott & Cockerell), *Eriococcus calvus* Ferris.

Field Characteristics: Adult females reddish-purple, without crystalline rods or other visible dorsal waxes; ovisac loosely woven and filamentous. Normally found on roots and

crowns of host.

Hosts: Creosote bush (*Larrea divaricata*).

Distribution: Mohave, Kern County, California; Arizona, New Mexico, Texas.

Economic Importance: None.

Diagnosis: Host preference and the following

characteristics aid in recognition: 4 setae on the hind tibiae, anal lobes unsclerotized, lateral enlarged setae 1 per each segment margin, lateral enlarged setae strongly curved and much larger than dorsal enlarged setae, legs unusually large.

***Acanthococcus mackenziei* Miller and Miller, 1992**
McKenzie eriococcin

Fig. 97

Hosts: Roots and crowns of *Eriogonum latifolium*.

Distribution: Known only from Lava Beds National Monument, Siskiyou County.

Economic Importance: None.

Diagnosis: Recognized by 4 setae on each hind tibia, large numbers of truncate dorsal setae, and absence of dorsal cruciform pores.

***Acanthococcus macrobactrus* Miller and Miller, 1992**
long rod eriococcin

Fig. 98

Field Characteristics: Adult females white or yellow, with many long crystalline rods of dorsal wax. Occurs on the young growth of the host, its long dorsal rods causing it to closely resemble the hairy surfaces of the host.

Hosts: *Arctostaphylos canescens*.

Distribution: Known only from Mt. Tamalpais,

Marin County.

Economic Importance: None.

Diagnosis: Recognized by 6 setae on each meso- and metathoracic tibia, 7 setae on each prothoracic tibia, 5 or 6 ventral setae on each anal lobe, and large numbers of ventral body setae on other segments.

***Acanthococcus palustris* (Dodds), 1923**
long rod eriococcin

Fig. 99

Synonymy:

Eriococcus palustris Dodds, *Nidularia palustris* (Dodds).

Field Characteristics: Adult females violet grey, occurring on the upper leaf surfaces (Dodds 1923); ovisacs white, turning to grey if wetted by salt water. According to Miller and Miller (1992), "This species occurs in a very unusual habitat for an eriococcid. It is known

only from the high tide level of San Francisco Bay where it may be subject to short periods of submersion."

Hosts: *Spartina foliosa*.

Distribution: Known only from Almonte, Marin County, but may occur in other coastal habitats wherever cord grasses (*Spartina*) occur.

Economic Importance: None.

Diagnosis: Recognized by 4 or fewer setae on hind tibiae, larger dorsal setae restricted to lateral areas of head and anal lobes, and dorsal multilocular pores.

Dodds, C.T., 1923: J. Entomol. Zool. 15:57-60.

Acanthococcus pittospori (Ferris), 1955
pittosporum eriococcin

Fig. 100

Synonymy:

Eriococcus pittospori Ferris.

Field Characteristics: Adult females reddish-brown, ovisacs tan with occasional yellow markings. Usually found on the bark and occasionally leaves of the host.

Hosts: *Pittosporum*, *Coprosma*.

Distribution: San Francisco, in and adjacent

to Golden Gate Park. Possibly introduced from Australia.

Economic Importance: None.

Diagnosis: Recognized by host plant preference and the following characteristics: only 2 setae on the hind tibiae, enlarged setae very broad basally, dorsal enlarged setae nearly the same size as lateral enlarged setae.

Acanthococcus quercus (Comstock), 1881
oak eriococcin

Fig. 101, Color Plate 98-99

Synonymy:

Rhizococcus quercus Comstock, *Eriococcus quercus* (Comstock), *Eriococcus howardi* Ehrhorn, *Eriococcus quercus* var. *gilensis*, *Nidularia quercus* (Comstock).

Field Characteristics: Adult females dark reddish-purple with a lighter median longitudinal stripe; ovisac white. Found primarily on the young growth and smaller branches.

Hosts: Oak (*Quercus*).

Distribution: Generally distributed in Cali-

fornia and the United States.

Economic Importance: None.

Diagnosis: Host plant preference and the following characteristics aid in identification: 5 setae on the hind tibiae, quinquelocular pores are the most prevalent type of multilocular pore, all enlarged setae nearly the same shape, enlarged setae with acute apices and strongly curved, and tibiae at least 1-1/2 times length of tarsi.

Acanthococcus salarius (Ferris), 1955
salt eriococcin

Fig. 102

Synonymy:

Eriococcus salarius Ferris.

Field Characteristics: Adult females purple. Occurs on host crowns and roots.

Hosts: Shad scale (*Atriplex*).

Distribution: Arid areas of Inyo, Los Angeles, and San Bernardino Counties.

Economic Importance: None.

Diagnosis: Host plant preference and the following characteristics aid in identification:

5 setae on the hind tibiae, all enlarged setae of nearly equal size, enlarged setae fusiform or bluntly rounded apically (bullet-shaped).

Acanthococcus texanus (King), 1902
Texas eriococcin

Fig. 103

Synonymy:

Eriococcus texanus King, *Eriococcus bahiae* Ehrhorn, *Nidularia texanus* (King), *Nidularia bahiae* Ehrhorn, *Rhizococcus texanus* (King).

Field Characteristics: Not known.

Hosts: Polyphagous.

Distribution: Inyo and Santa Clara Counties, California; Arizona, Texas, New Mexico.

Economic Importance: None.

Diagnosis: This species has the following characteristics: 5 setae on the hind tibiae, multilocular pores predominantly with more than 5 loculi, lateral enlarged setae much larger than the dorsal enlarged setae, dorsal enlarged setae moderately curved.

Acanthococcus tinsleyi (Cockerell), 1898
Tinsley eriococcin

Fig. 104

Synonymy:

Eriococcus tinsleyi Cockerell, *Nidularia tinsleyi* (Cockerell).

Field Characteristics: Adult females light brownish-purple, often striped longitudinally and with many long crystalline wax rods dorsally; ovisac yellowish-white. Occurs on crowns and roots of host.

Hosts: Polyphagous, but seems to prefer *Atriplex* and *Chrysothamnus*.

Distribution: Riverside County, California; Arizona, Idaho, New Mexico, Texas.

Economic Importance: None.

Diagnosis: Host plant preference and the following characteristics aid in identification: 4 setae on the hind tibiae, all enlarged setae nearly equal in size and slightly curved, enlarged setae not arranged in longitudinal lines on the abdomen, largest lateral setae with blunt apices, and cruciform pores abundant.

Genus *Atriplicia* Cockerell & Rohwer, 1909

One species native to the southwestern United States. The key provided here on page 155 and by Miller & McKenzie (1967) will aid in recognizing the genus. It will also be found in Ferris (1955) in the key to *Eriococcus*.

Ferris, G.F., 1955: Atlas of the Scale Insects of North America. Vol. 7. Stanford Univ. Press, Stanford. 233 pp.

Miller, D.R. and H.L. McKenzie, 1967: Hilgardia 38(13):471-539.

Atriplicia gallicolus Cockerell & Rohwer, 1909
atriplex gall scale

Fig. 105

Synonymy:

Eriococcus gallicolus (Cockerell & Rohwer).

Hosts: Lives in and apparently is the cause of galls at the bases of the leaves of shad scale (*Atriplex*).

Distribution: Deep Springs, Inyo County; Colorado, New Mexico.

Economic Importance: None.

Diagnosis: Host plant preference and gall-forming habits plus the following characteristics aid in the recognition of this species: anal lobes well developed, dorsal quinquelocular pores present, dorsal and lateral setae not typically enlarged.

Genus *Cornoculus* Ferris, 1955

A small genus with only two species, one from Texas and one from southern California. Recognized by the clusters of macrotubular ducts on the ventral margins of the abdomen. For a key to the species, see Miller & McKenzie (1967).

Miller, D.R. and H.L. McKenzie, 1967: Hilgardia 38(13):471-539.

Cornoculus densus Miller, 1967
dense-character ovaticoccin

Fig. 106

Hosts: Grass, *Hilaria rigida*.

Distribution: San Bernardino and Imperial Counties.

Economic Importance: None.

Diagnosis: Recognized by the very dense

arrangement of dermal structures on the dorsum and venter, the dome-like dorsal enlarged setae and the extremely long regular body setae.

Genus *Eriococcus* Targioni-Tozzetti, 1869

This genus formerly contained the North American species that are now placed in the genus *Acanthococcus*. For more information see the above comments under that genus. There are numerous species from the Old World which are still included in the genus, but none are known from the New World. The species treated in the above key, "*Eriococcus*" *gillettei*, has been placed in the Kermesidae by Miller (1983) in spite of the very similar morphological appearance to the Eriococcidae. It is covered in the chapter on the Kermesidae.

Miller, D. R. 1983: In Kaszab, Z. Verhanl. Zehnten Inter. Symp. Entomofaunistik Mitteleuropas, 420 pp.

Genus *Gossyparia* Signoret, 1875

There are four species in this genus according to Hoy (1963). One species, *G. spuria*, is known from California and the United States, where it was introduced from Europe. One other species is known from Eurasia and two are known from Australia. The genus, long separated from *Eriococcus* because of the near total absence of dorsal tubular macroducts, was placed in *Eriococcus* by Williams (1985) because of the overall similarity in morphology. Miller & Miller (1992) have resurrected the genus because of the absence of dorsal macroducts and especially because *G. spuria* has a chromosome number of 28 compared with *Acanthococcus* species, which so far have a number of 18 or fewer.

This genus can be recognized by the following morphological characteristics: anal lobes present and strongly produced; dorsal quinquelocular pores absent; dorsal enlarged setae numerous, large and spine-like; dorsal macroducts absent except for a few ducts along the postero-lateral edges of some segments.

Hoy, J.M., 1963: N. Z. Dep. Sci. Ind. Res. Bull. 150:1-260.

Miller, D. R. and G.L. Miller, 1992: Trans. Amer. Entomol. Soc. 118(1):1-106.

Williams, D.J. 1985: Bull. Brit. Mus, (Nat. Hist.), Entomol. Ser. 51:347-393.

***Gossyparia spuria* (Modeer), 1778
European elm scale (ESA approved)**

Fig. 107, Color Plates 100-104

Other Common Names:

Elm-tree scale, elm bark louse.

Synonymy:

Coccus ulmi Linnaeus, *Coccus spurius* Modeer, *Coccus laniger* Gmelin, *Coccus gramuntii* Planchon, *Chermes ulmi* (Linnaeus), *Nidularia lanigera* (Gmelin), *Nidularia gramuntii* (Planchon), *Gossyparia ulmi* (Linnaeus), *Gossyparia gramuntii* (Planchon), *Gossyparia spuria* (Modeer), *Eriococcus spurius* (Modeer).

Field Characteristics: Adult females 1.5 to 3.0 mm long; oval; dark purple to reddish-brown. Soon after molting into the adult stage, the females begin to secrete the characteristic white, nest-like ovisac which covers the ventral surface and sides of the insect and extends partially inward as tooth-like extensions along the segmental lines toward the midline. Immature individuals brownish and covered with transparent wax spines similar to those found in other eriococcids. Immatures cryptic and not easily noticed. Males form oblong,

woolly white puparia, usually in groups isolated from the females.

Biology: Usually found on twigs and branches, particularly on undersides of branches and in bark cracks, although many early instar nymphs also feed on leaves. One generation per year; winter spent as late instar female nymphs and second stage males. Maturity completed in March and April; egg-laying continues from May through August. Each female may produce up to 400 eggs, which are laid a few at a time over the summer. Nymphs hatch and begin moving about within hours after the eggs are laid. The above biological information summarized from List (1920), Herbert (1924), Essig (1958), and Brown & Eads (1966).

Similar Species: None. Host preferences and field characteristics should separate it from all other California scale insects.

Hosts: Almost totally restricted to elms in the genus *Ulmus*. Listed from hackberry (*Celtis*) and *Zelkova*, both in the elm family. There is

one unusual confirmed record from a pear tree (*Pyrus*) in Arlington, Virginia, listed by Baer (1977). The European authors list several other hosts according to Herbert (1924), but these hosts have not been recorded in the United States.

Economic Importance: A serious pest of elms. It removes large quantities of plant sap, causing general debilitation, yellowing of the leaves, and the death of smaller branches. The copious honeydew coats the trees and objects beneath them. It is very sticky and is a nuisance because it is unpleasant to walk on and must be washed from lawn furniture, cars, etc. It also favors the growth of unsightly sooty mold. The above economic information summarized in part from Hillman (1895), List (1920), Herbert (1924), Mackie (1930), and Brown & Eads (1966). Biological control of this species has been attempted, but it has not been particularly successful (see Bartlett, 1978). For other information on biological control see Kosztarab & Kozár (1988) and Viggiani (1990).

Distribution: Generally distributed in California and the United States. Also widespread in Europe; probably native to the European or Eurasian areas.

Diagnosis: Host plant preference and field

appearance easily separate this species from all other California scale insects. It differs from similar *Acanthococcus* species by lacking dorsal macrotubular ducts except for a few along the postero-lateral margins of some segments.

Baer, R. G., 1977: U.S. Dep. Agric. Coop. Plant Pest Rep. 2(33):647.
Bartlett, B. R., 1978: U.S. Dep. Agric. Handb. 480:1-545.
Brown, L. R. and C. O. Eads, 1966: Calif. Agric. Exp. Stn. Bull. 821:1-24.
Essig, E. O., 1958: Insects and Mites of Western North America. The MacMillan Co., New York. 1050 pp.
Herbert, F. B., 1924: U.S. Dep. Agric. Bull. 1223:1-19.
Hillman, F. H., 1895: Nev. State Univ. Agric. Exp. Stn. Bull. 28:1-8.
Kosztarab, M and F. Kozár, 1988: Scale insects of Western Europe. Dr. W. Junk, The Netherlands. 456 pp.
List, G. M., 1920: Colo. Agric. Coll. Circ. 29:1-12.
Mackie, D. B., 1930: Calif. Dep. Agric. Mon. Bull. 19(8):547-556.
Viggiani, G., 1990: Bull. Soc. Entomol. Suisse 63:281-285.

Genus *Oregmopyga* Hoy, 1963

The name *Oregmopyga* replaces the name *Onceropyga* Ferris, 1955, which was preoccupied. The genus contains 6 species, nearly all from the southwestern United States and adjacent areas of Mexico. The genus is recognized by having a red body, weakly produced, unsclerotized anal lobes and dorsal quinquelocular pores. For a key to the species, see Miller & McKenzie (1967).

Miller, D. R. and H. L. McKenzie, 1967: Hilgardia 38(13):471-539.

Key to the California species of *Oregmopyga*

- 1. Anal ring non-cellular 2
- Anal ring cellular 3

- 2. Microtubular ducts absent from venter; anal ring dorsal with three pairs very small setae *neglecta*

- Microtubular ducts present on venter; anal ring apical with three pairs of long, conspicuous setae *sanguinea*
- 3. Antennae 6-segmented; anal ring circular or nearly so; dorsal enlarged setae broader *eriogoni*
- Antennae 7-segmented; anal ring U-shaped; dorsal enlarged setae narrower . . *johnsoni*

Oregmopyga eriogoni Miller, 1967
eriogonum ovaticoccin

Fig. 108, Color Plate 105

Hosts: *Eriogonum*.
Distribution: Los Angeles, Riverside, San Bernardino, and San Diego Counties.
Economic Importance: None.
Diagnosis: Host plant preference and the fol-

lowing morphological characteristics aid in recognition: cellular anal ring, translucent pores on both dorsal and ventral surfaces of the hind coxae, 6-segmented antennae.

Oregmopyga johnsoni Miller, 1967
Johnson's ovaticoccin

Fig. 109

Hosts: Compositae; prefers *Hymenoclea salsola* and *Gutierrezia sarothrae*.
Distribution: Generally distributed in central and southern California.
Economic Importance: None.
Diagnosis: Host plant preferences and the

following morphological characteristics aid in recognition: cellular anal ring, translucent pores on both dorsal and ventral surfaces of the hind coxae, recessed (invaginated) dorsal enlarged setae, 7-segmented antennae.

Oregmopyga neglecta Cockerell, 1895
neglected ovaticoccin

Fig. 110, Color Plate 106

Synonymy:
Eriococcus neglectus Cockerell, *Nidularia neglecta* (Cockerell), *Onceropyga neglecta* (Cockerell).
Hosts: Chenopodiaceae, especially *Atriplex*.
Distribution: Generally distributed in the arid areas of southern California, Arizona, New Mexico, and Texas.

Economic Importance: None.
Diagnosis: Host plant preference and the following morphological characteristics aid in identification: anal ring non-cellular and possessing 3 pairs of very short setae, cruciform pores absent, many setae on the anal lobes, 6-segmented antennae.

Oregmopyga sanguinea Miller, 1967
bright-red ovaticoccin

Fig. 111

Hosts: *Haplopappus acradenius*.
Distribution: Thousand Palms Canyon, Riverside County.
Economic Importance: None.
Diagnosis: Host restriction and the following

characteristics aid in identification: bright red body (nearly as dark as in some *Dactylopius*), anal ring non-cellular and possessing 3 pairs of long setae, microtubular ducts present on venter.

Genus *Ovaticoccus* Kloet, 1944

The name *Ovaticoccus* replaces the name *Gymnococcus* Cockerell, 1894, which was preoccupied. For more information on this, see Kloet (1944). The genus contains eight North American species, most of which occur in the arid regions of the southwestern United States. The genus can be recognized by the lack of anal lobes, non-cellular anal ring, and small numbers of dermal pores and ducts. For a key to the North American species, see Miller & McKenzie (1967).

Kloet, G.S., 1944: Entomol. Mon. Mag. 80:86.
Miller, D.R. and H. L. McKenzie, 1967: Hilgardia 38(13):471-539.

Key to the California species of *Ovaticoccus*

1. With at least 10 enlarged setae 2
— Usually without enlarged setae 5

2. Dorsal quinquelocular pores present 3
— Dorsal quinquelocular pores usually absent 4

3. Antennae 6-segmented; ventral cruciform pores on lateral margins; microcruciform pores numerous near hind coxae *salviae*
— Antennae 7-segmented; ventral cruciform pores in transverse bands on abdomen; microcruciform pores absent *agavium*

4. Macrotubular ducts absent; abdomen with not more than two pairs of enlarged setae per segment *parkerorum*
— Macrotubular ducts present; abdomen with three or four pairs of enlarged setae per segment *variabilis*

5. Microtubular ducts usually absent, may be few on abdominal margin *californicus*
— Microtubular ducts present 6

6. Dorsal quinquelocular pores absent; antennae 6-segmented *senarius*
— Dorsal quinquelocular pores present; antennae usually 7-segmented *mackenziei*

Ovaticoccus agavium (Douglas), 1888
agave ovaticoccin

Fig. 112, Color Plate 107

Synonymy:
Coccus agavium Douglas, *Gymnococcus agavium* (Douglas), *Ripersia agavium* (Douglas),

Pseudantonina agaves Chiaromonte.
Field Characteristics: Adult females 0.5 to 1.0 mm long, oval; lightly dusted with white pow-

dery wax; pinkish; with 2 longitudinal rows of brownish blotches. Usually completely hidden at bases of leaves and often found in such large populations that they are also hidden among and under the coalesced white filamentous ovisacs of previous populations. Males form white silken cocoons singly in the open along the undersides of leaves. Biology: Unknown, except that there are apparently continuous overlapping generations (Boratynski, 1958).

Similar Species: Probably cannot be separated in the field from other *Yucca* or *Agave* infesting eriococcins such as *Ovaticoccus californicus*. The mealybug *Cataenococcus olivaceus* (Cockerell) is found on similar hosts, but is usually much larger and darker. The pinkish color of this species, the habit of hiding at the leaf bases beneath the matted ovisacs, and the placement of the male cocoons should aid in the field recognition of this species at least to the generic level.

Hosts: *Yucca*, *Agave*, and *Aloe*.

Economic Importance: A rare species; not generally a pest. However, honeydew production, sooty mold development, and the presence of the woolly ovisacs and male pu-

paria make infested plants appear unsightly. Valuable specimen plants and nursery stock may, therefore, require treatment.

Distribution: Apparently native to the arid regions of the southwestern United States, including southeastern California. Has been found in a number of suburban areas of southern California on nursery stock. Has also been introduced on the East Coast of the United States and into Europe, Russia, and East Africa on nursery stock and specimen plants.

Diagnosis: Host plant preferences and the following morphological characteristics aid in recognition: with at least 10 enlarged setae, quinquelocular pores present, antennae 7-segmented, cruciform pores in transverse bands on venter of abdomen, microcruciform pores absent. The immature stages have been studied and described by Boratynski (1958); males have been studied in detail by Afifi (1968).

Afifi, S.A., 1968: Bull. Br. Mus. (Nat. Hist.), Entomol. Suppl. 13:1-209.

Boratynski, K.L., 1958: Proc. R. Entomol. Soc. London, Ser. B, 27:173-182.

Miller, D.R. and H.L. McKenzie, 1967: Hilgardia 38(13):471-539.

***Ovaticoccus californicus* McKenzie, 1964**
California ovaticoccin

Fig. 113

Hosts: *Yucca*, *Agave*, and *Baccharis*.

Distribution: Desert areas of Los Angeles, Riverside, San Bernardino, and San Diego Counties.

Economic Importance: None.

Diagnosis: Recognized by the absence of enlarged dorsal setae and micro-tubular ducts.

***Ovaticoccus mackenziei* Miller, 1967**
McKenzie's ovaticoccin

Fig. 114

Hosts: Mormon tea (*Ephedra*).

Distribution: Generally distributed in central and southern California.

Economic Importance: None.

Diagnosis: Host plant restriction and the follow-

ing morphological characteristics will aid in the recognition of this species: dorsal enlarged setae absent, microtubular pores present, dorsal quinquelocular pores present, antennae 7-segmented, dorsal cruciform pores absent.

Ovaticoccus parkerorum Miller, 1967
Parker ovaticoccin

Fig. 115

Hosts: *Haplopappus linearifolius*.

Distribution: Panoche Pass, San Benito County.

Economic Importance: None.

Diagnosis: The following characteristics distinguish this species: dorsal enlarged setae present, dorsal quinquelocular pores absent, macrotubular ducts absent.

Ovaticoccus salviae Miller, 1967
salvia ovaticoccin

Fig. 116

Hosts: Sage (*Salvia*).

Distribution: Orange, Riverside, and San Bernardino Counties.

Economic Importance: None.

Diagnosis: Host plant preference and the following morphological characteristics aid

in recognition: dorsal enlarged setae present, dorsal quinquelocular pores present, antennae 6-segmented, ventral cruciform pores restricted to lateral areas, microcruciform pores common near hind coxae.

Ovaticoccus senarius McKenzie, 1964
franseria ovaticoccin

Fig. 117

Hosts: *Franseria dumosa*.

Distribution: Riverside, San Bernardino, and San Diego Counties.

Economic Importance: None.

Diagnosis: Host plant restriction and the

following morphological characteristics aid in identification: without dorsal enlarged setae, microtubular ducts present, dorsal quinquelocular pores absent, antennae 6-segmented.

Ovaticoccus variabilis Miller, 1967
variable ovaticoccin

Fig. 118

Hosts: Primarily *Artemisia*.

Distribution: Generally distributed in northern and central California and eastward into Nevada and Montana.

Economic Importance: None.

Diagnosis: The following morphological characteristics aid in recognition: dorsal enlarged setae present, dorsal quinquelocular pores absent, macrotubular ducts present.

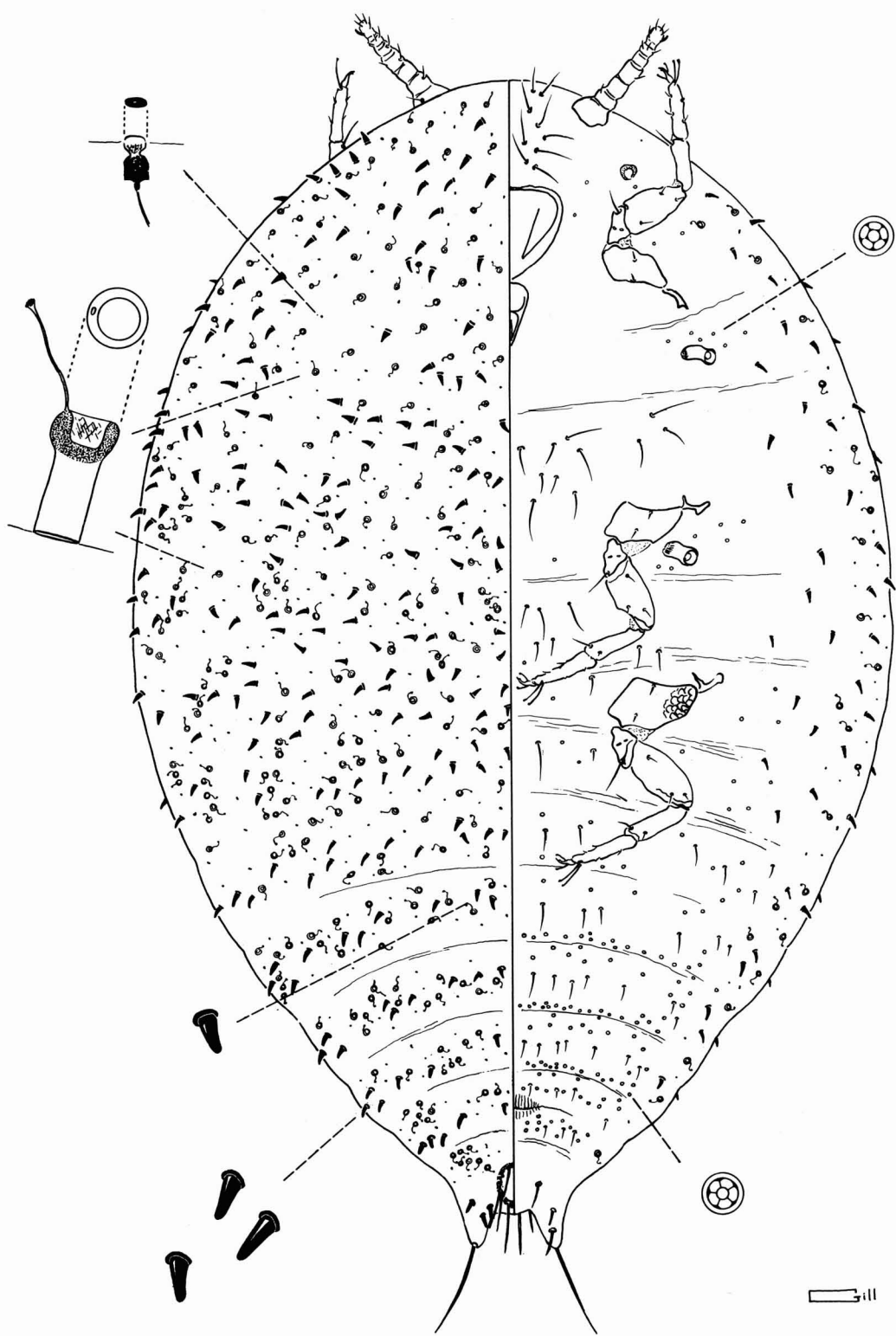


Fig. 80: *Acanthococcus adenostomae* (Ehrhorn).

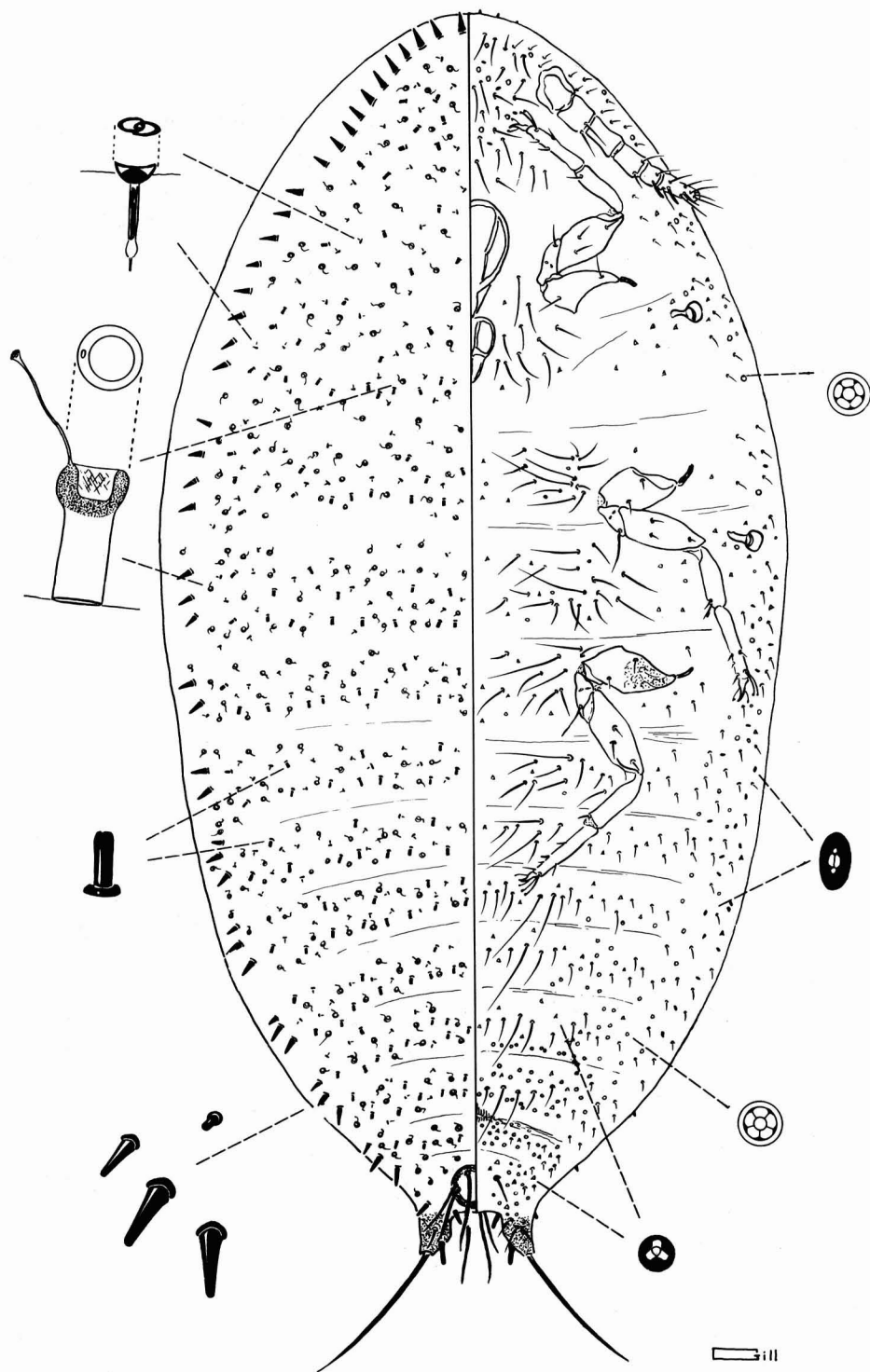


Fig. 81: *Acanthococcus araucariae* (Maskell).

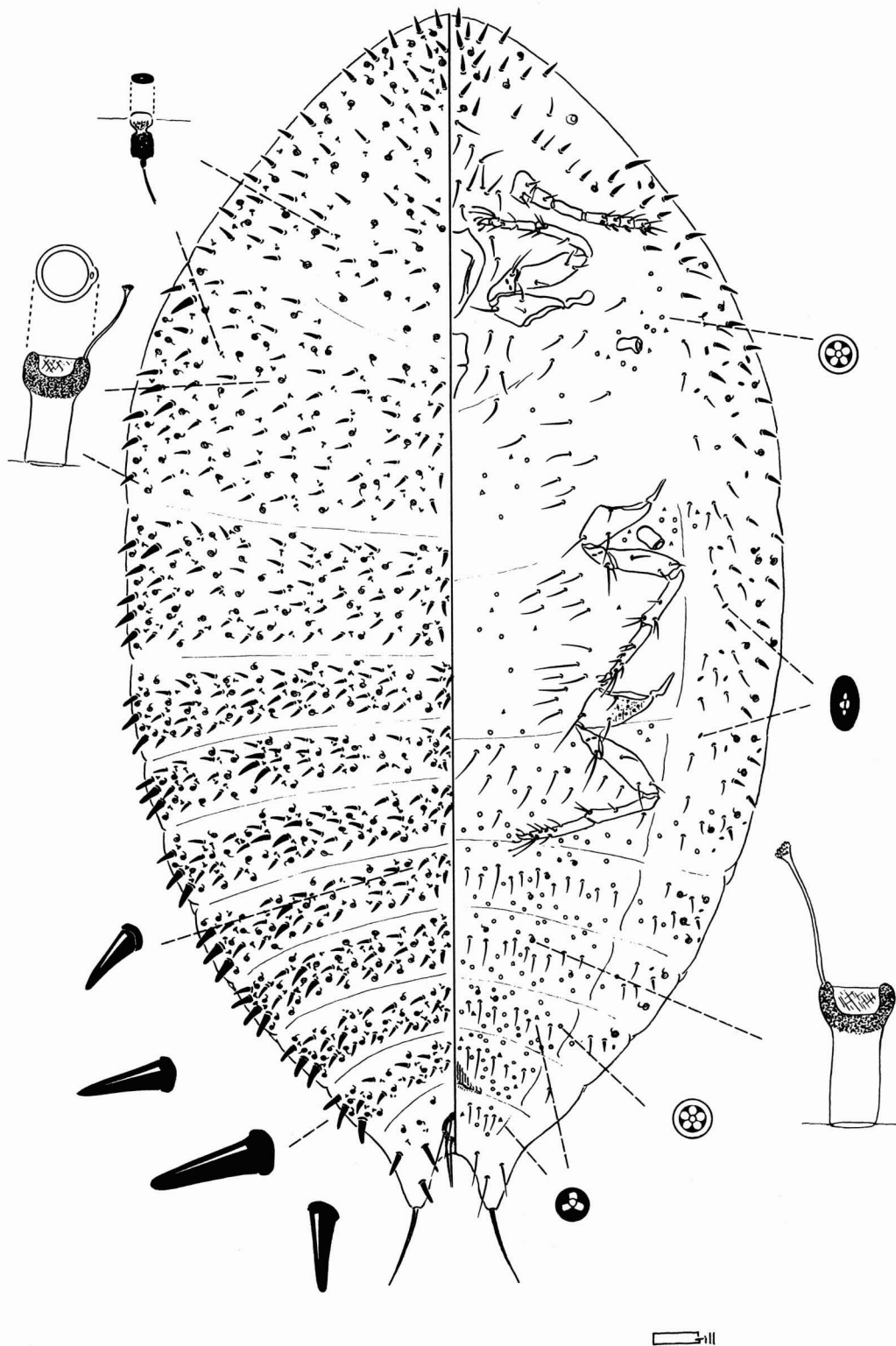


Fig. 82: *Acanthococcus arctostaphyli* (Ferris).

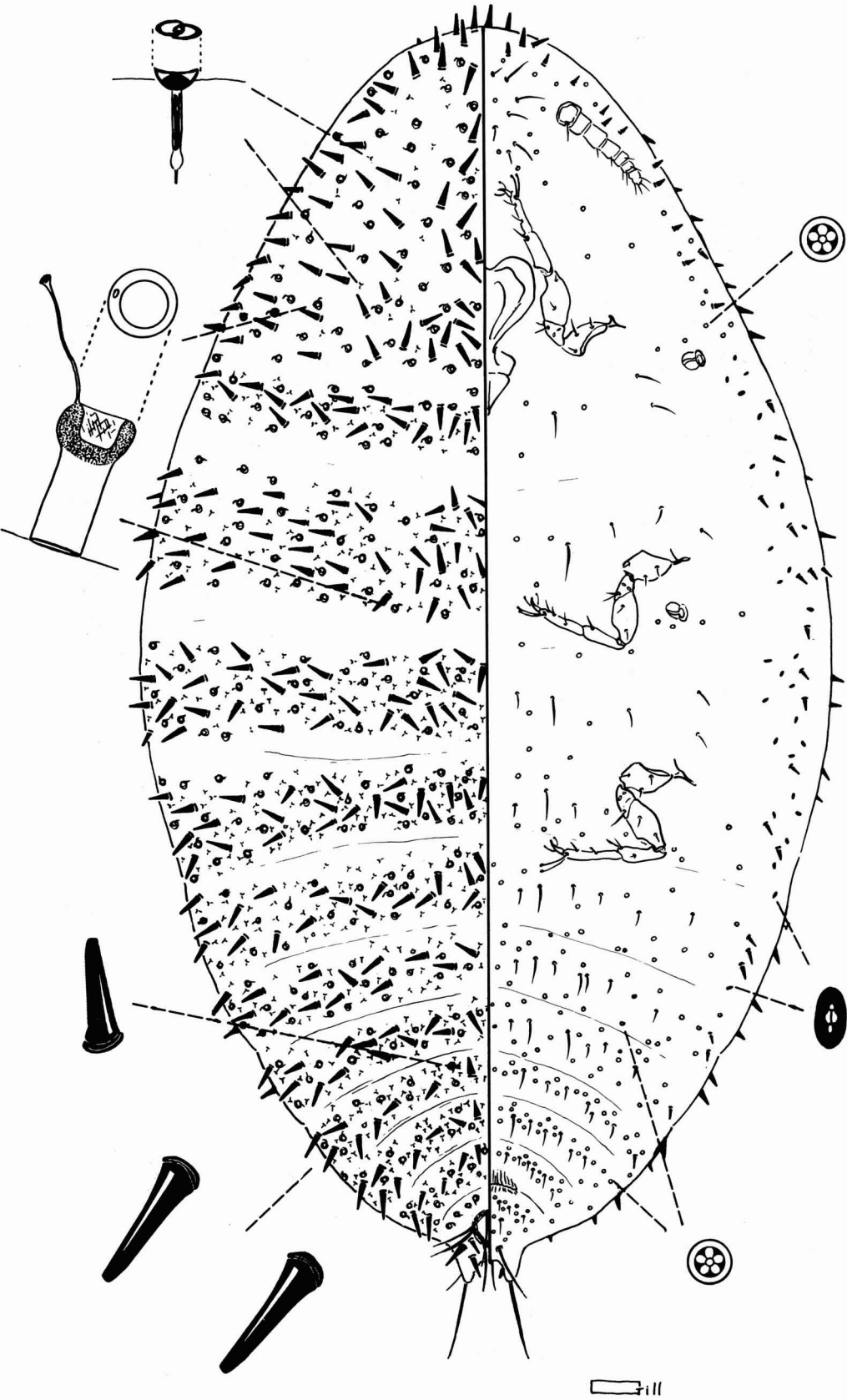


Fig. 83: *Acanthococcus azaleae* (Comstock).

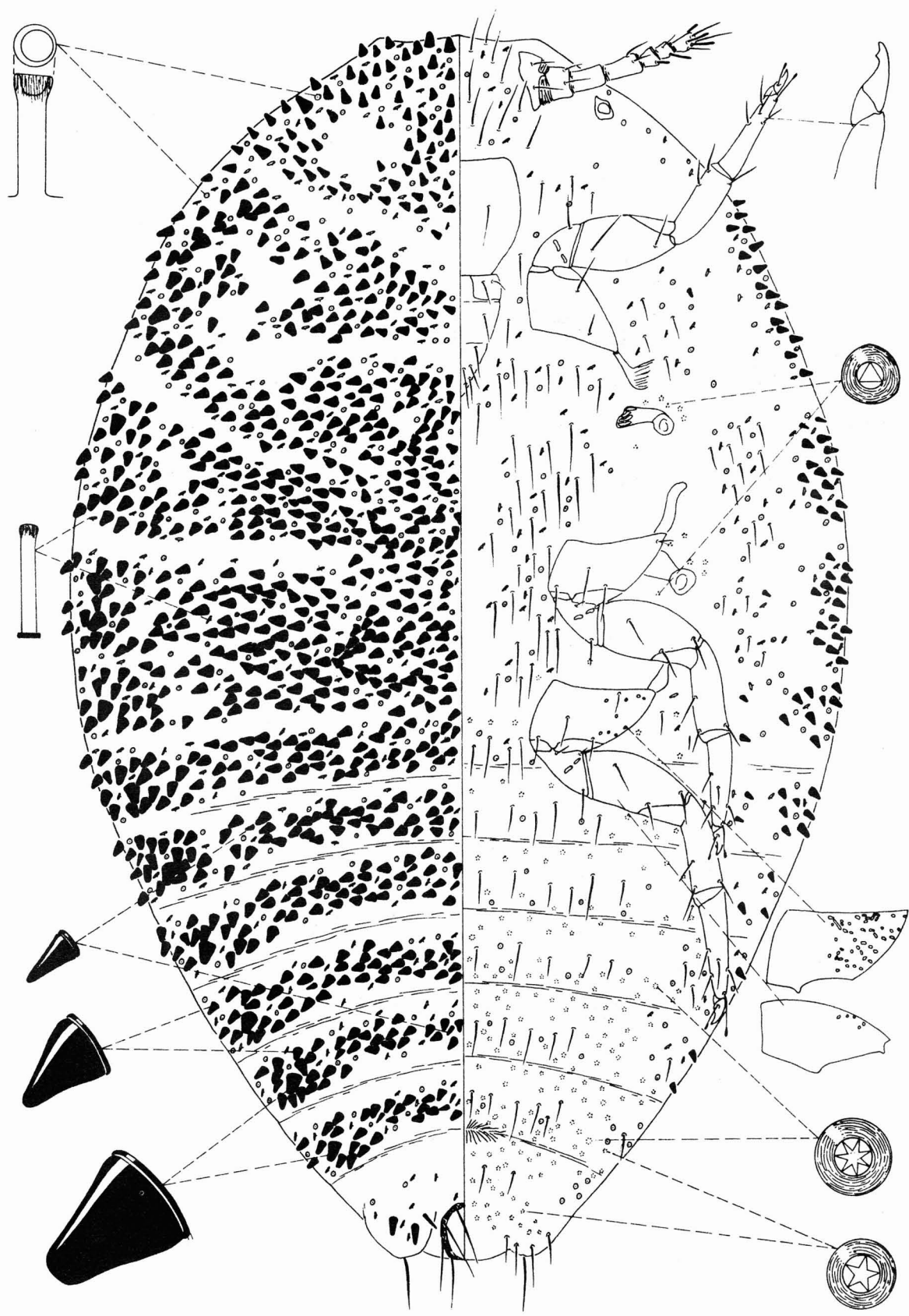


Fig. 84: *Acanthococcus barri* Miller (Figure courtesy of D.R. and G.L. Miller).

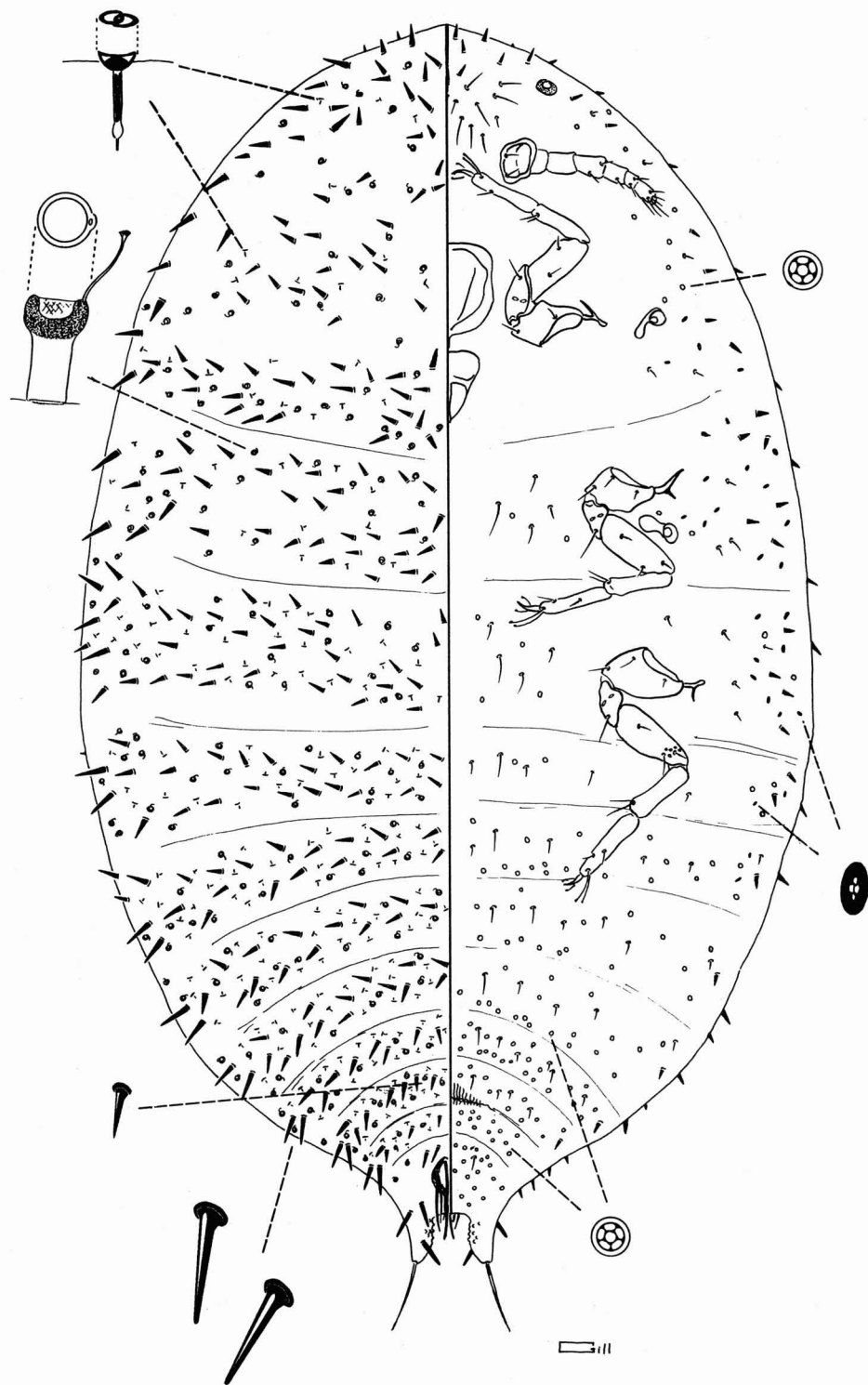
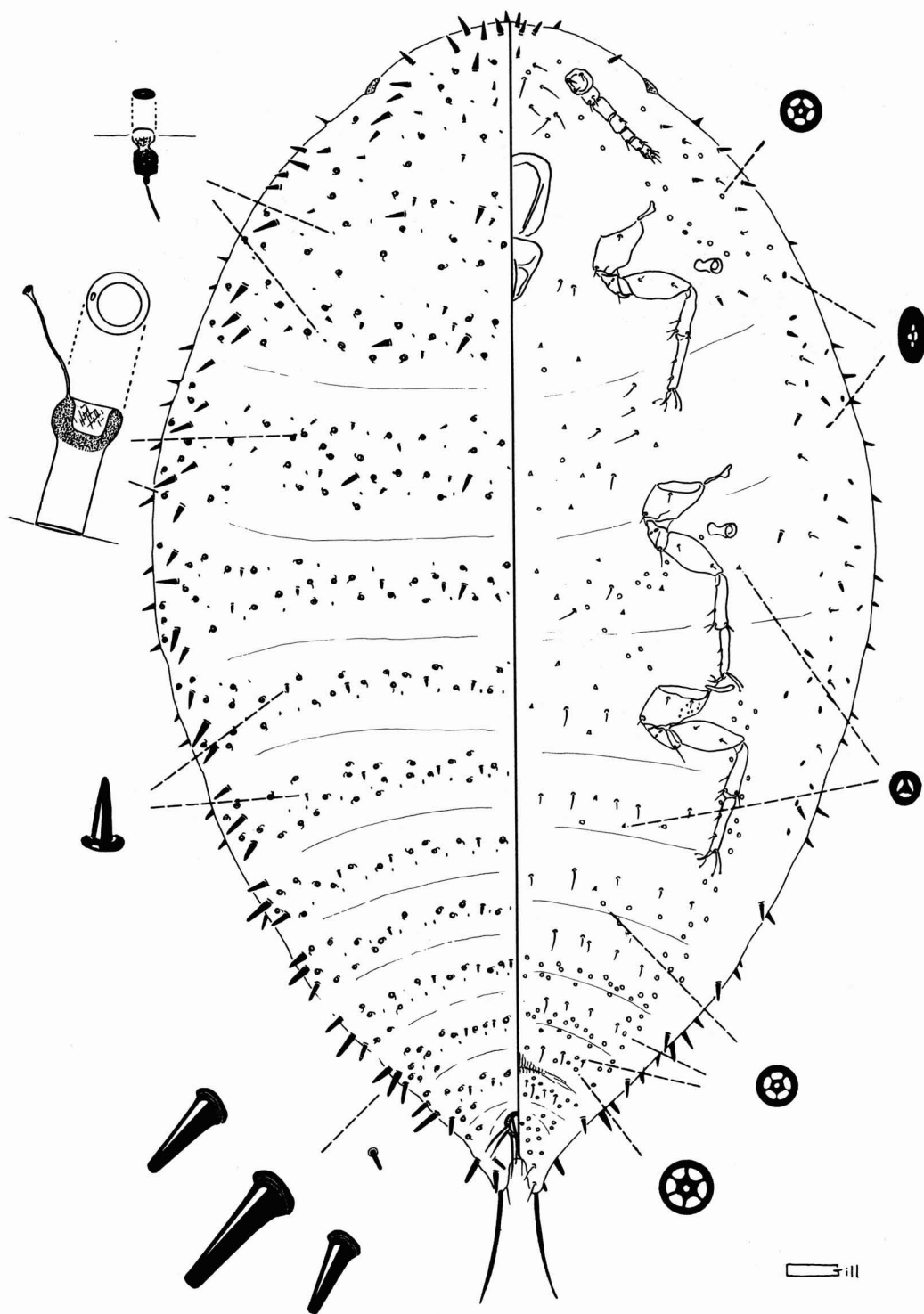


Fig. 85: "*Eriococcus*" *borealis* (Cockerell).



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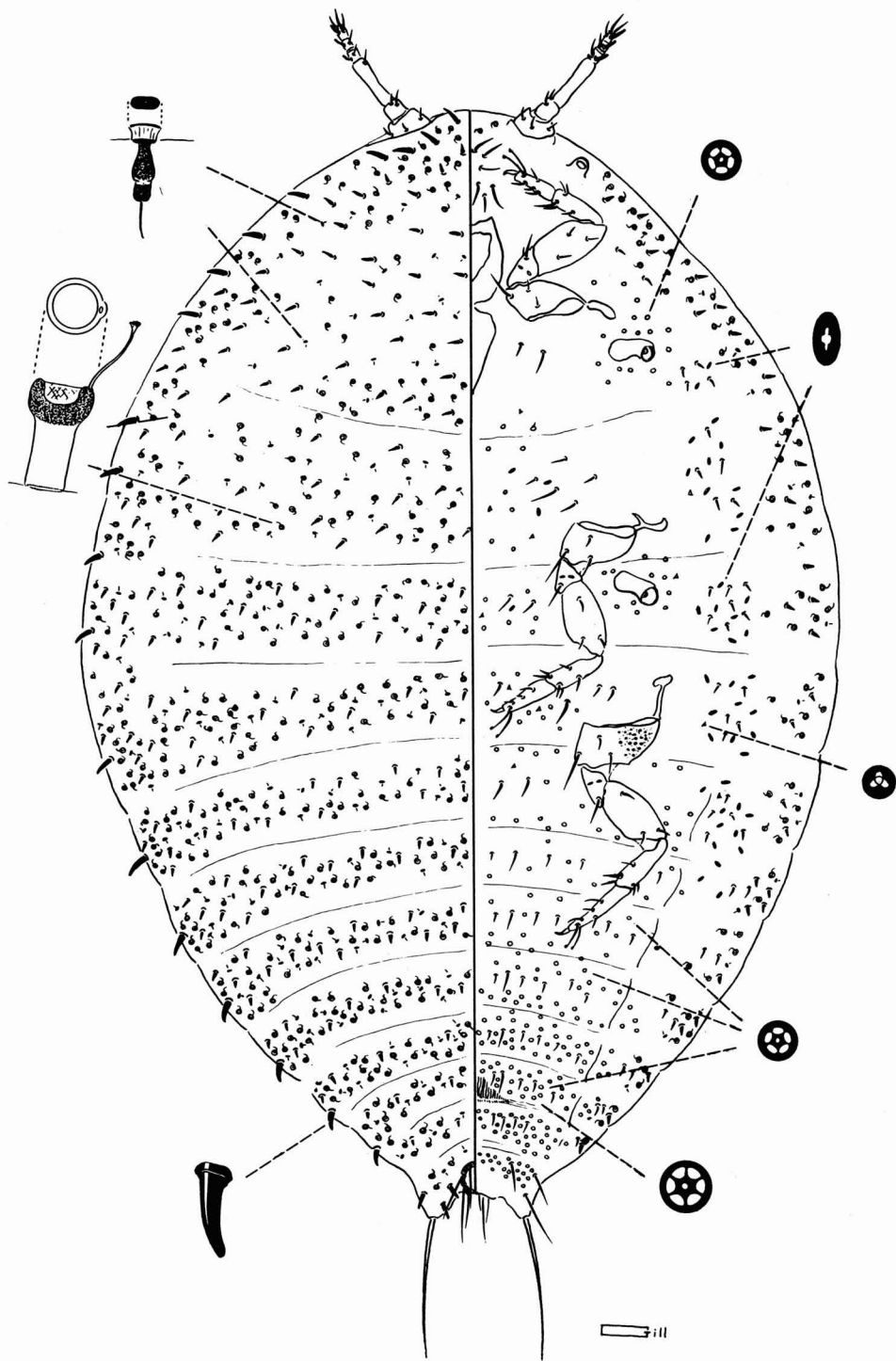


Fig. 87: *Acanthococcus cryptus* (Cockerell).

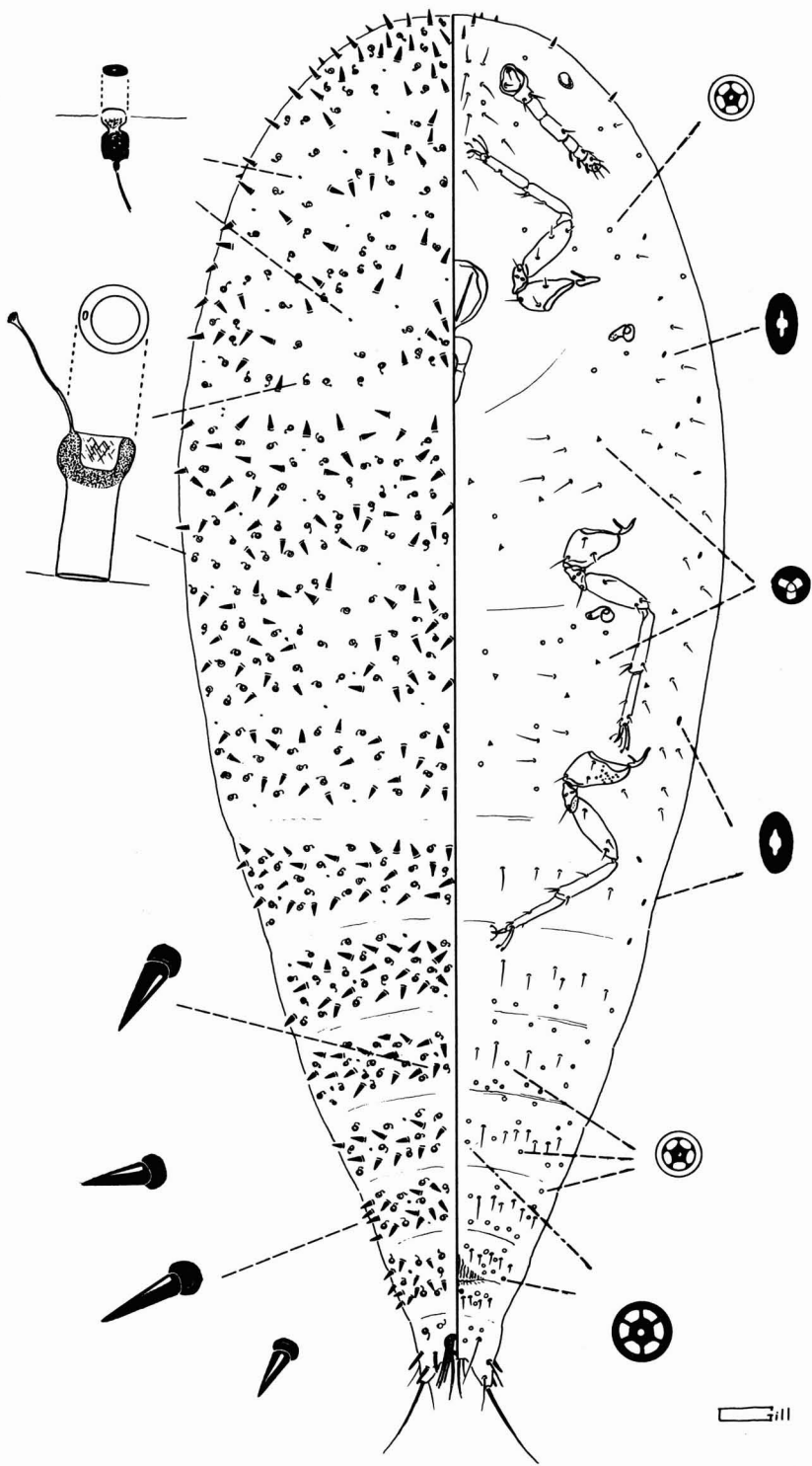


Fig. 88: *Acanthococcus diaboli* (Ferris).

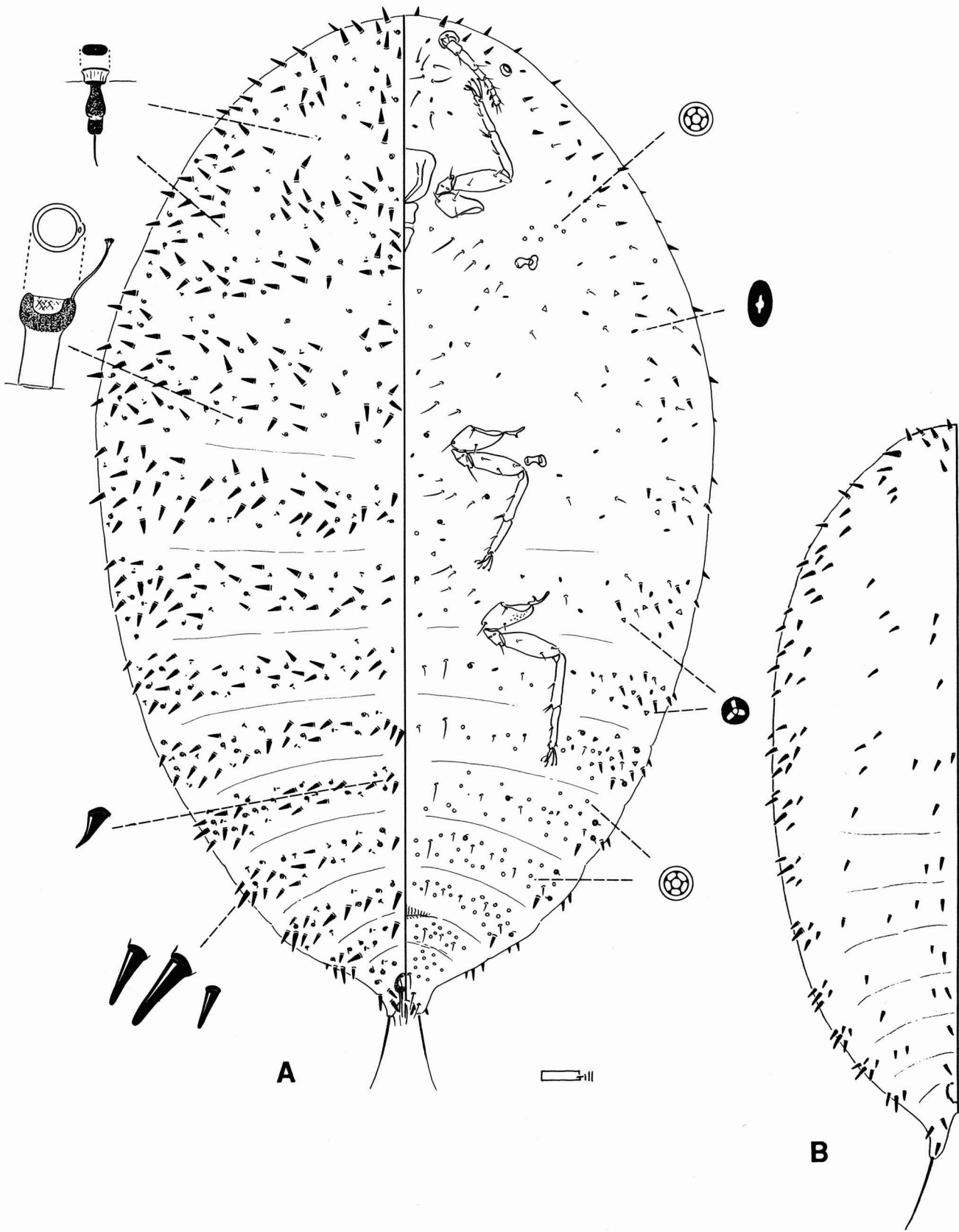


Fig. 89: *Acanthococcus dubius* (Cockerell). A. Adult morphology. B. Figure showing a variation in number and arrangement of dorsal enlarged setae.

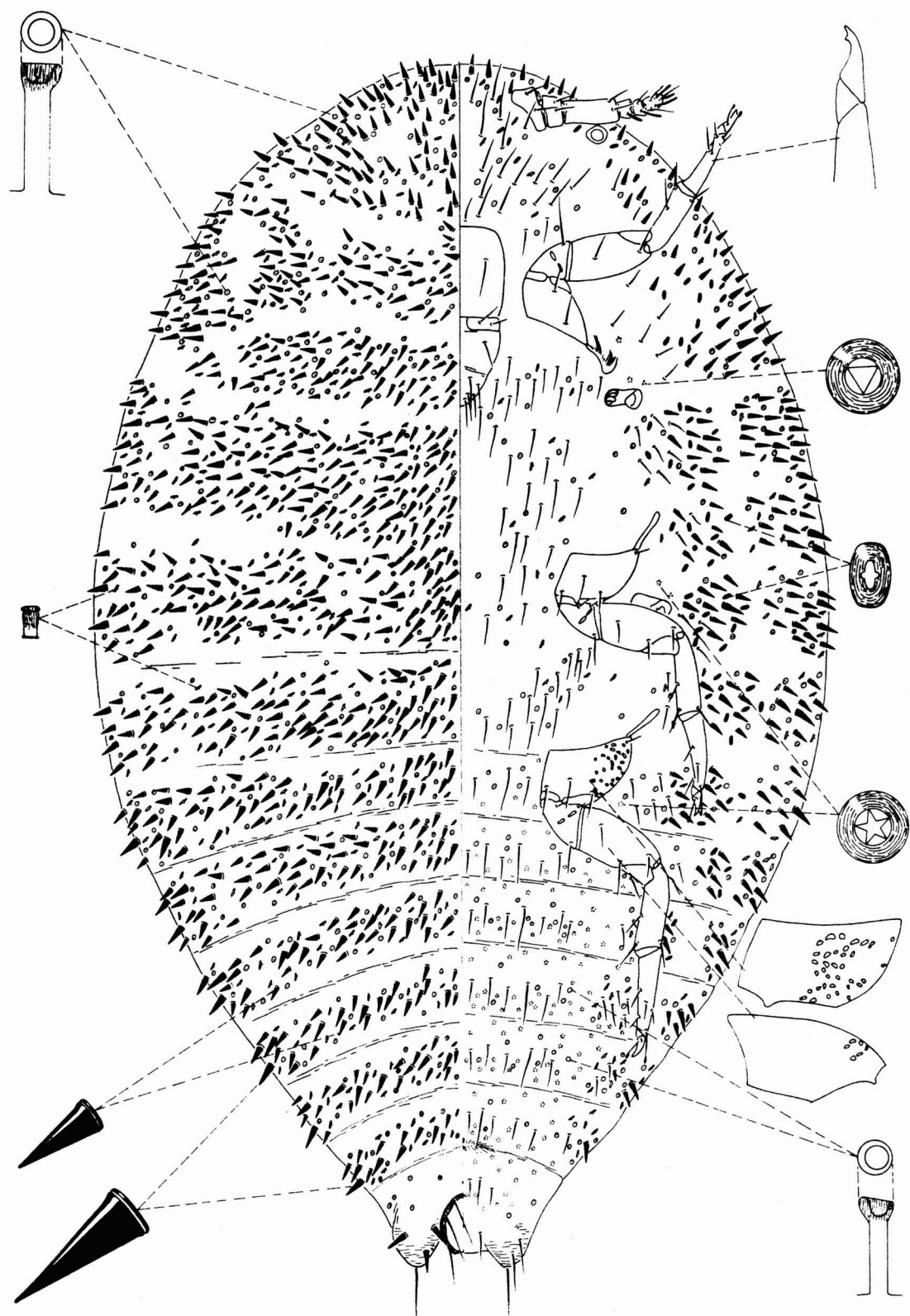


Fig. 90: *Acanthococcus epacrotrichus* Miller and Miller (Figure courtesy of D.R. and G.L. Miller).

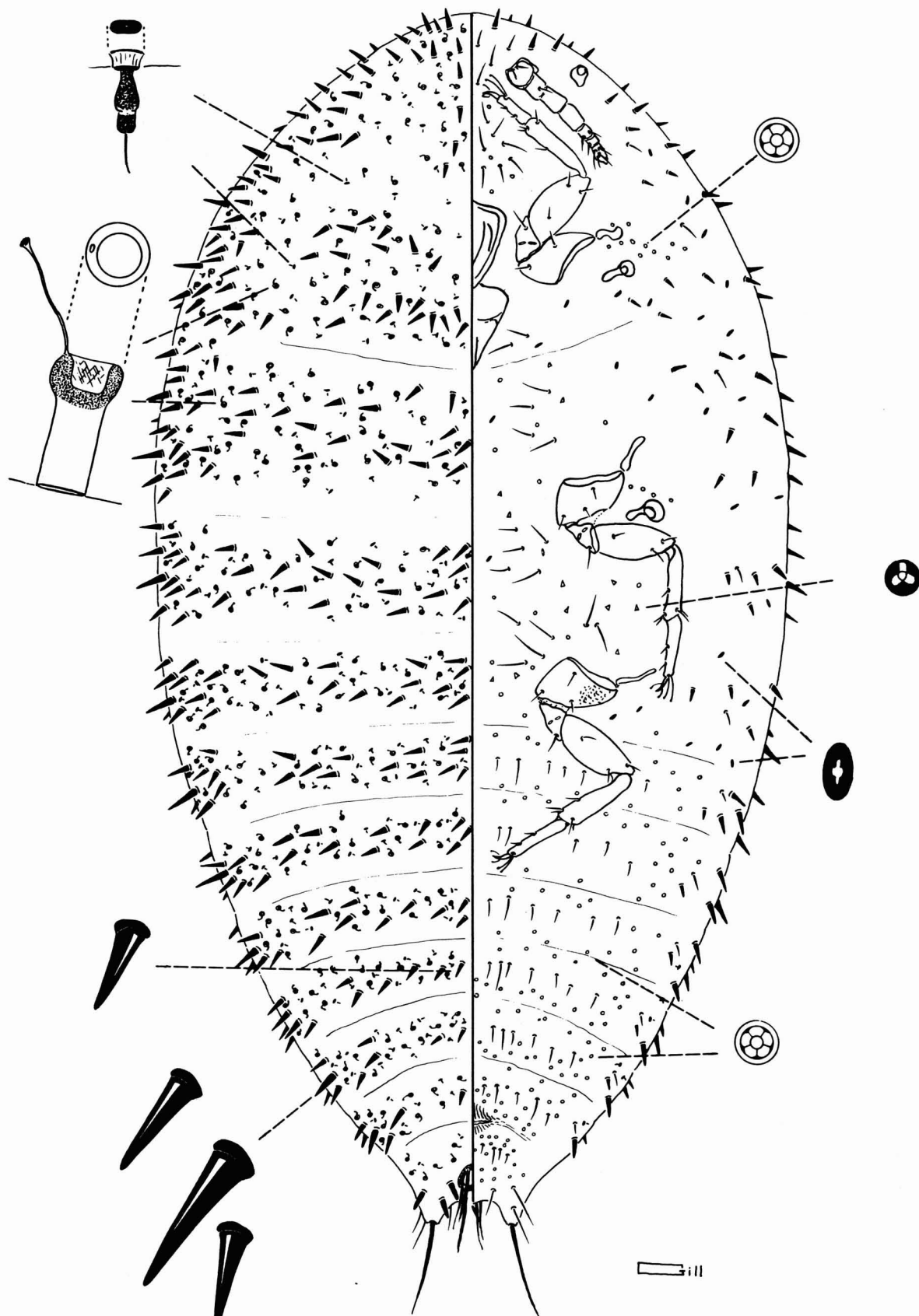


Fig. 91: *Acanthococcus eriogoni* (Ehrhorn).

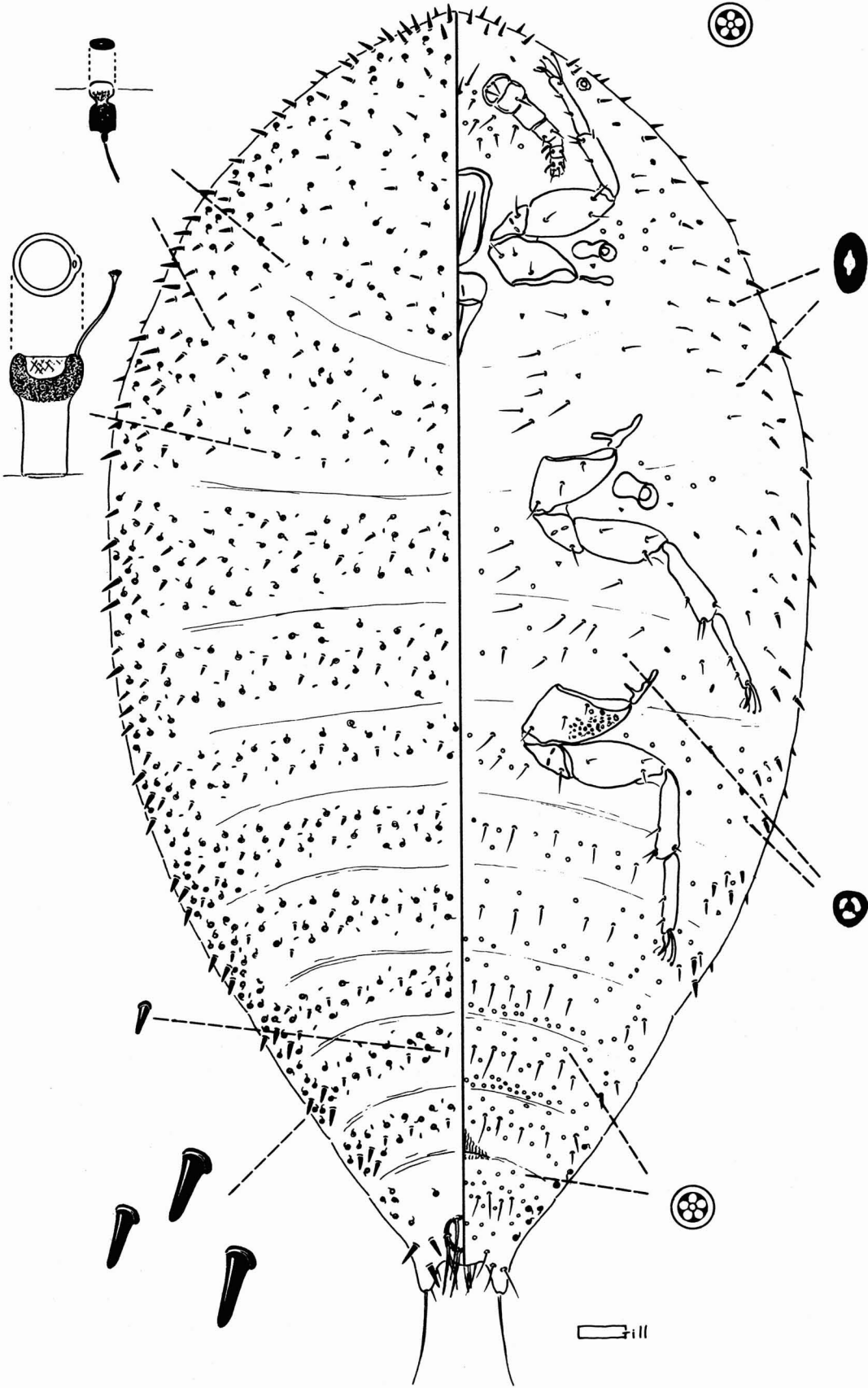


Fig. 92: *Acanthococcus euphorbiae* (Ferris).

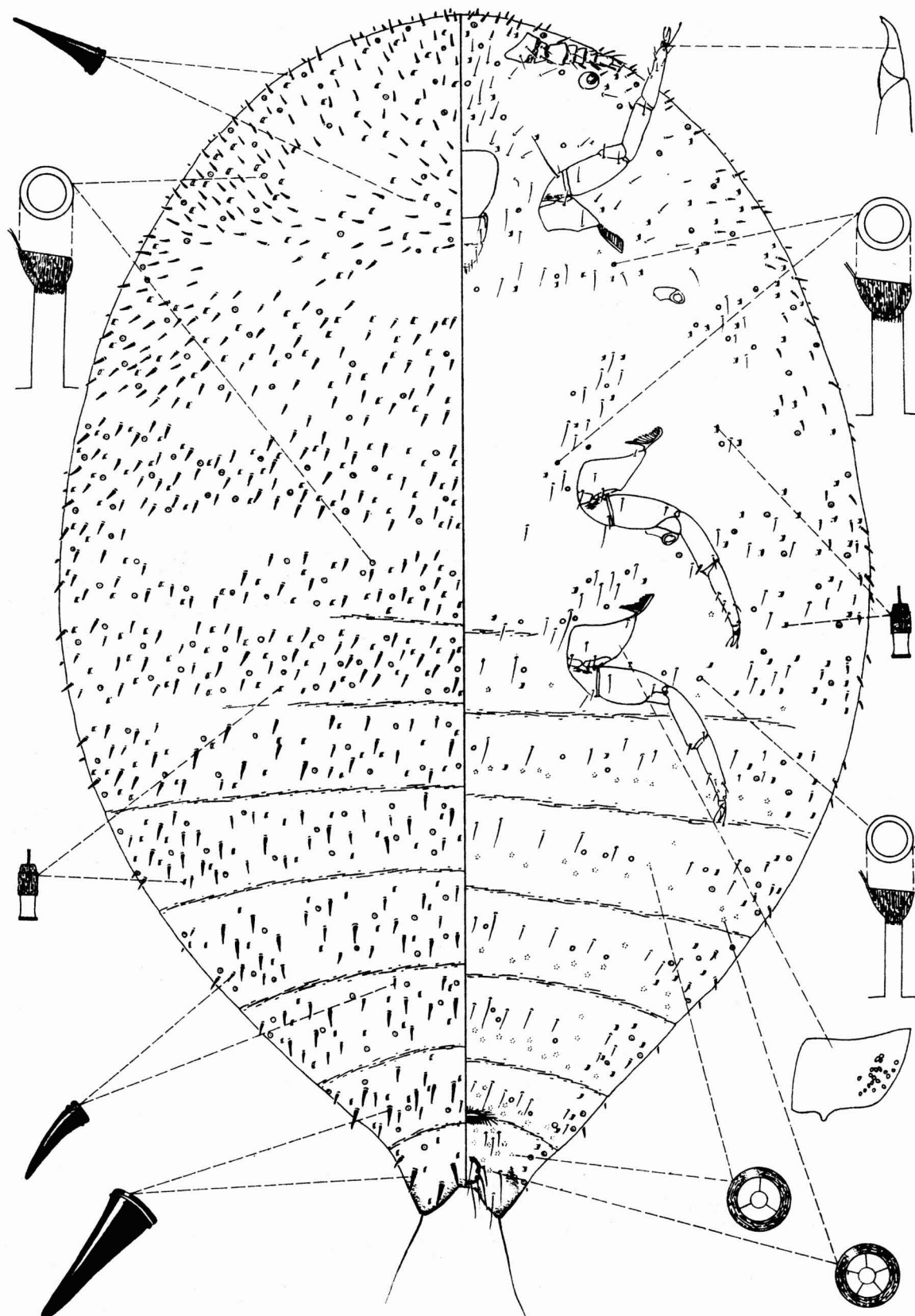


Fig. 93: *Acanthococcus freebeae* Miller (Figure courtesy of D.R. and G.L. Miller).

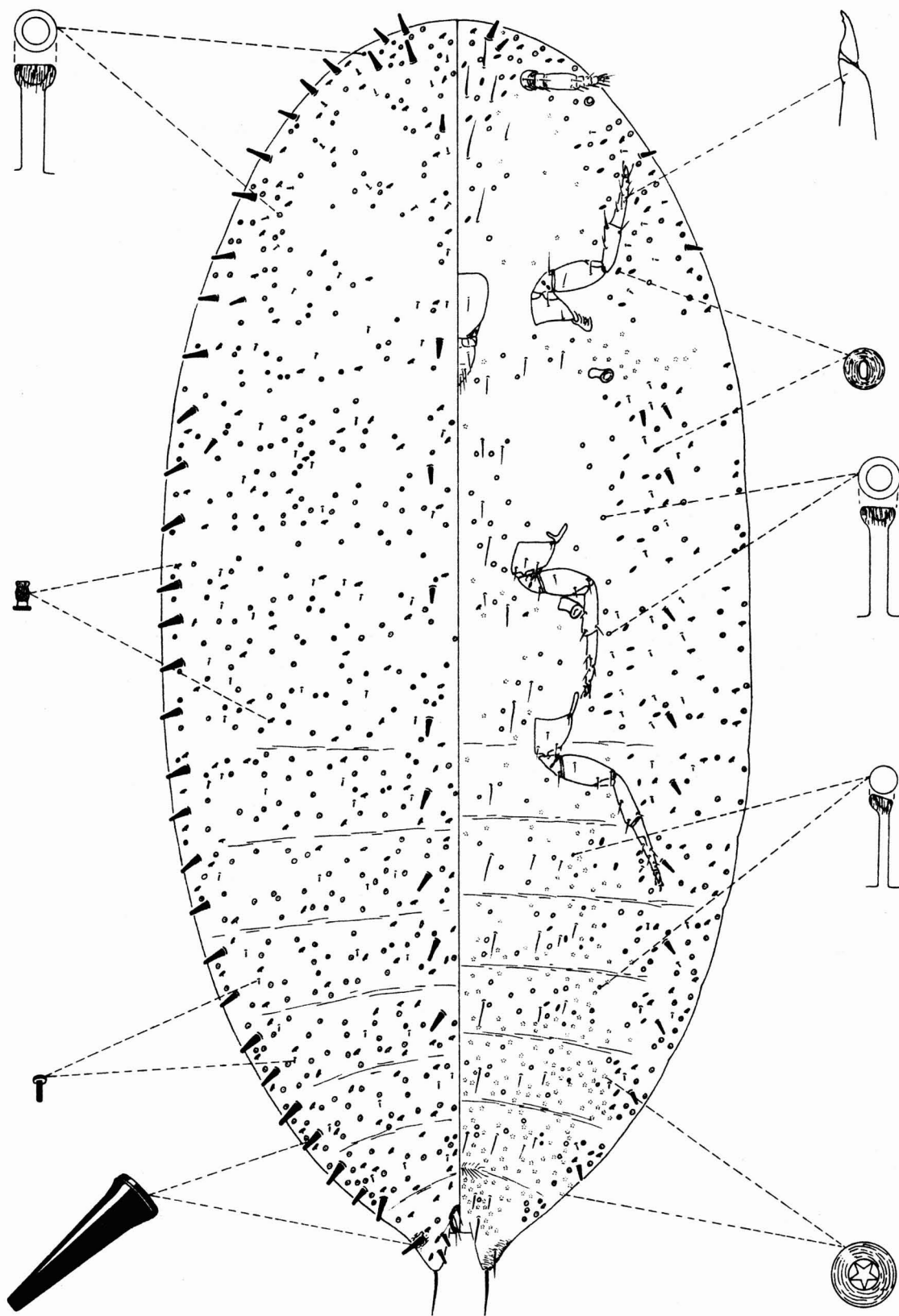


Fig. 94: *Acanthococcus hoyi* Miller and Miller (Figure courtesy of D.R. and G.L. Miller).

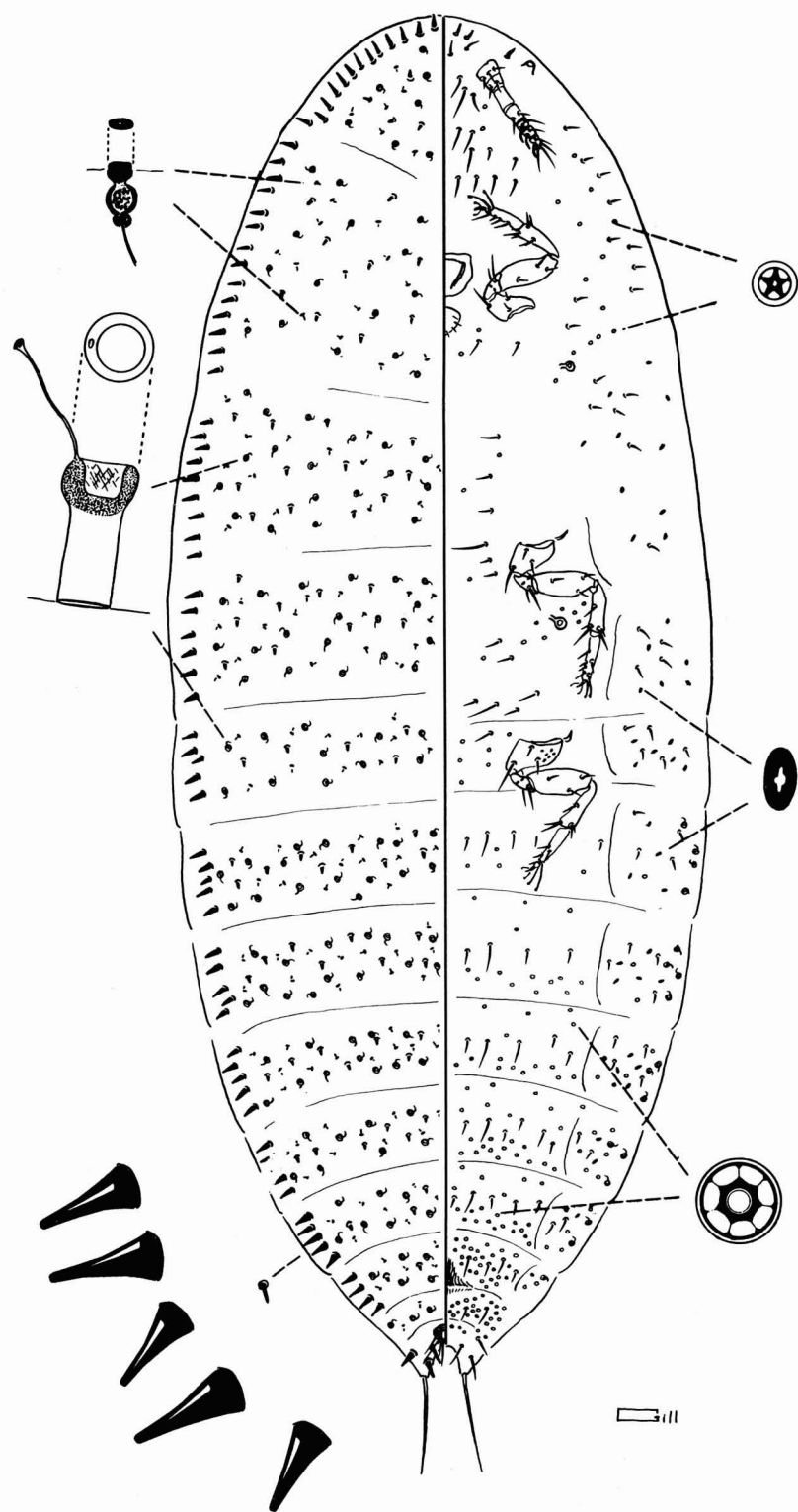


Fig. 95: *Acanthococcus insignis* (Newstead).

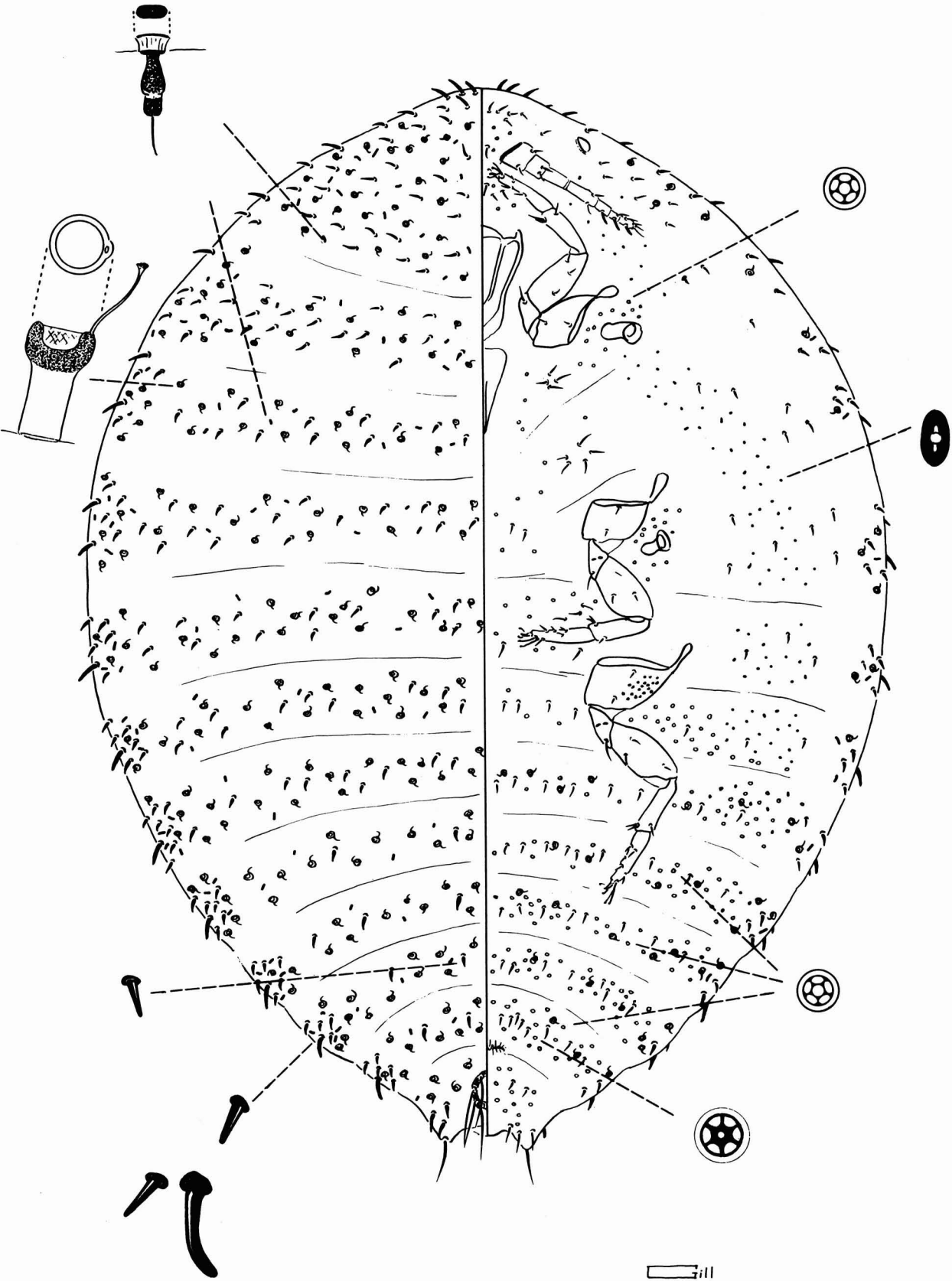


Fig. 96: *Acanthococcus larreae* (Parrott and Cockerell).

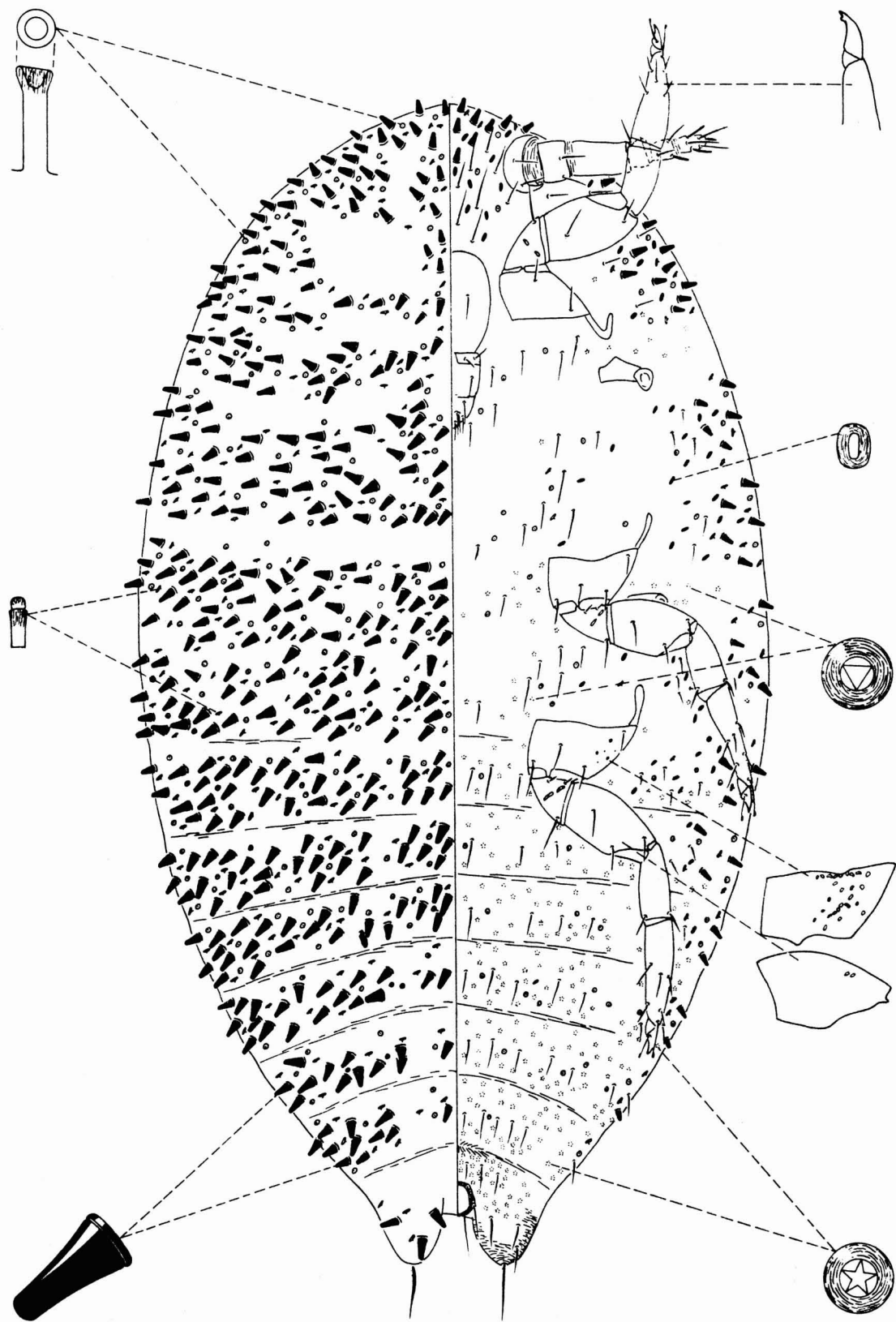
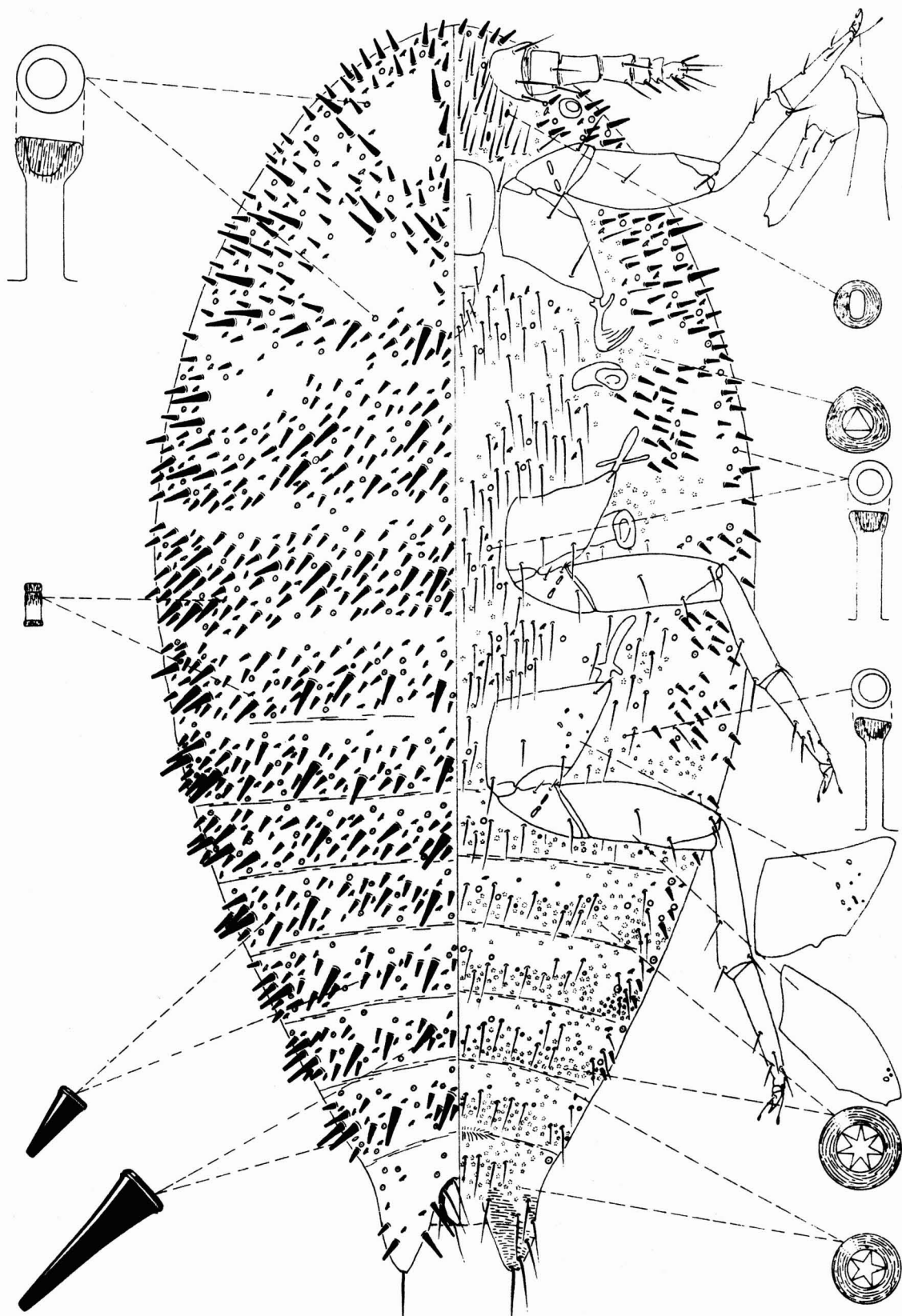


Fig. 97: *Acanthococcus mackenziei* Miller and Miller (Figure courtesy of D.R. and G.L. Miller).



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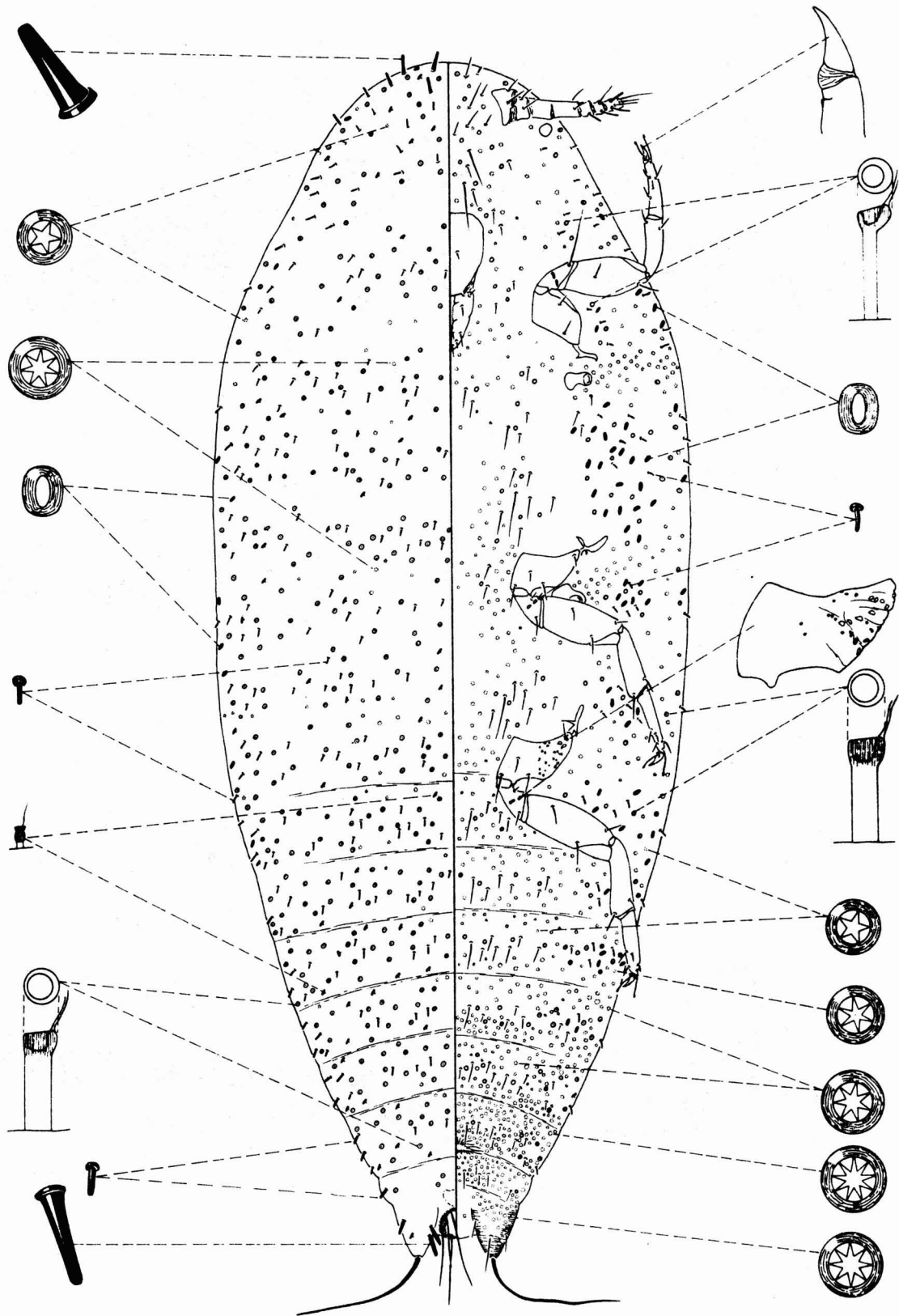


Fig. 99: *Acanthococcus palustris* (Dodds) (Figure courtesy of D.R. and G.L. Miller).

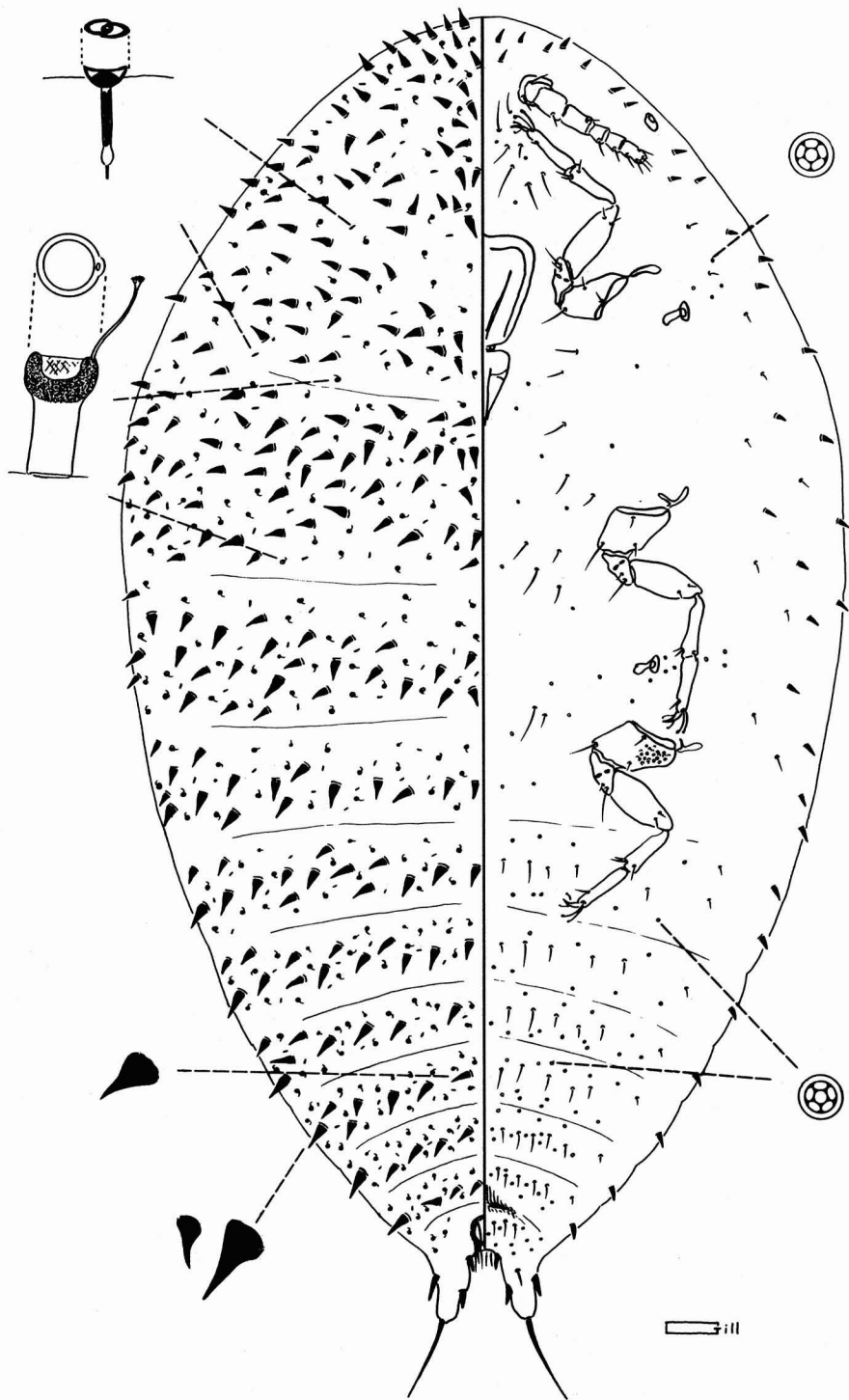


Fig. 100: *Acanthococcus pittospori* (Ferris).

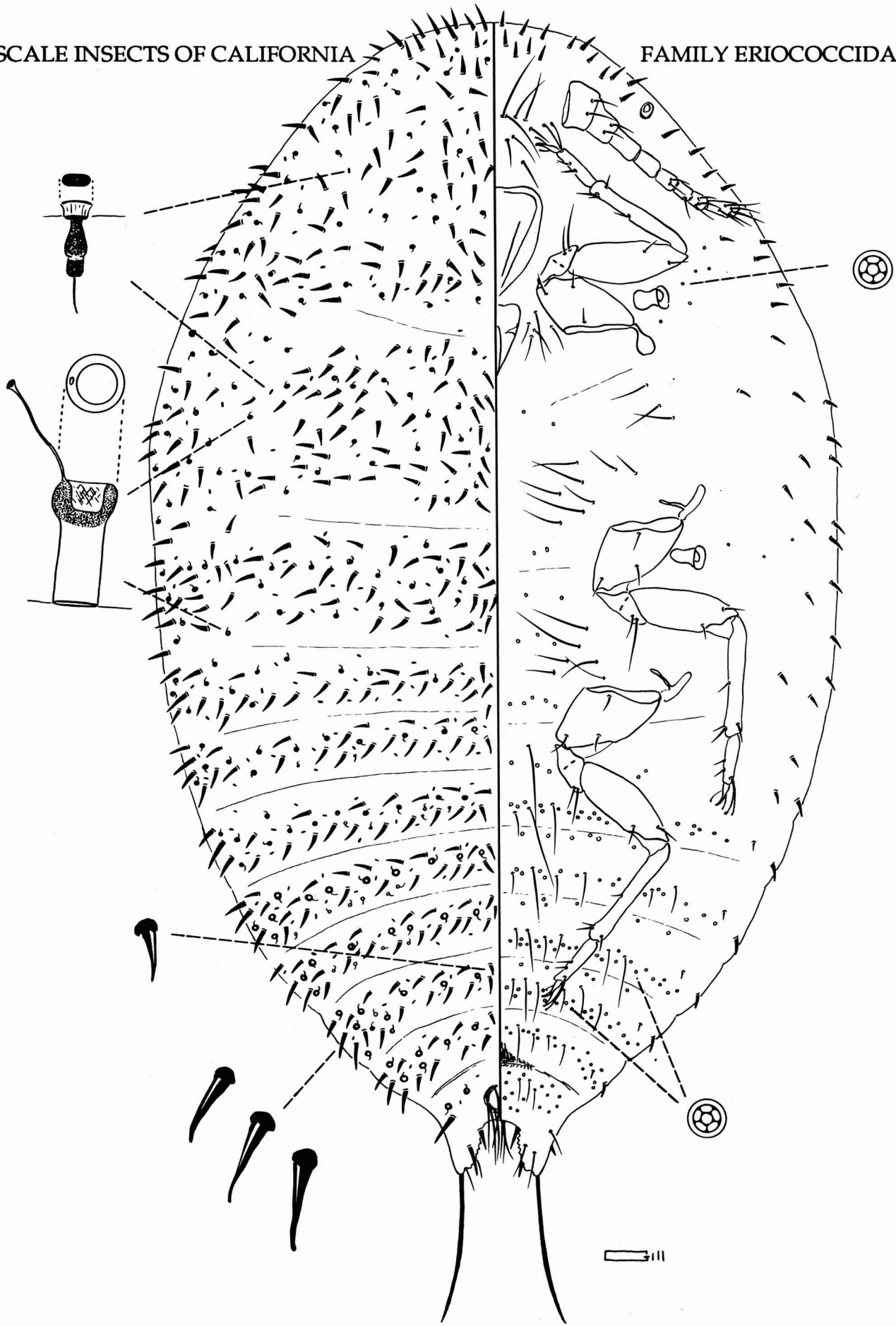


Fig. 101: *Acanthococcus quercus* (Comstock).

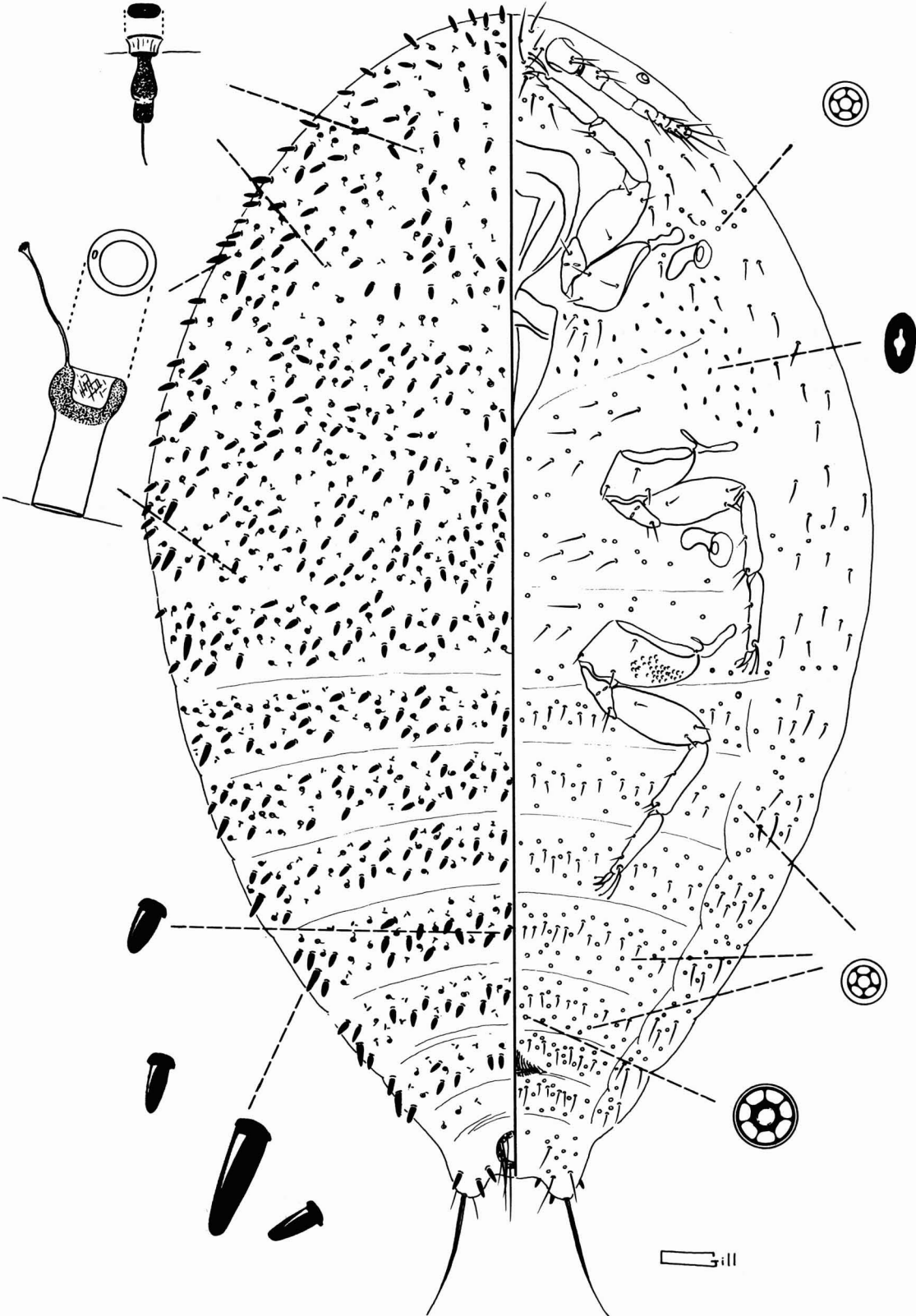


Fig. 102: *Acanthococcus salarius* (Ferris).

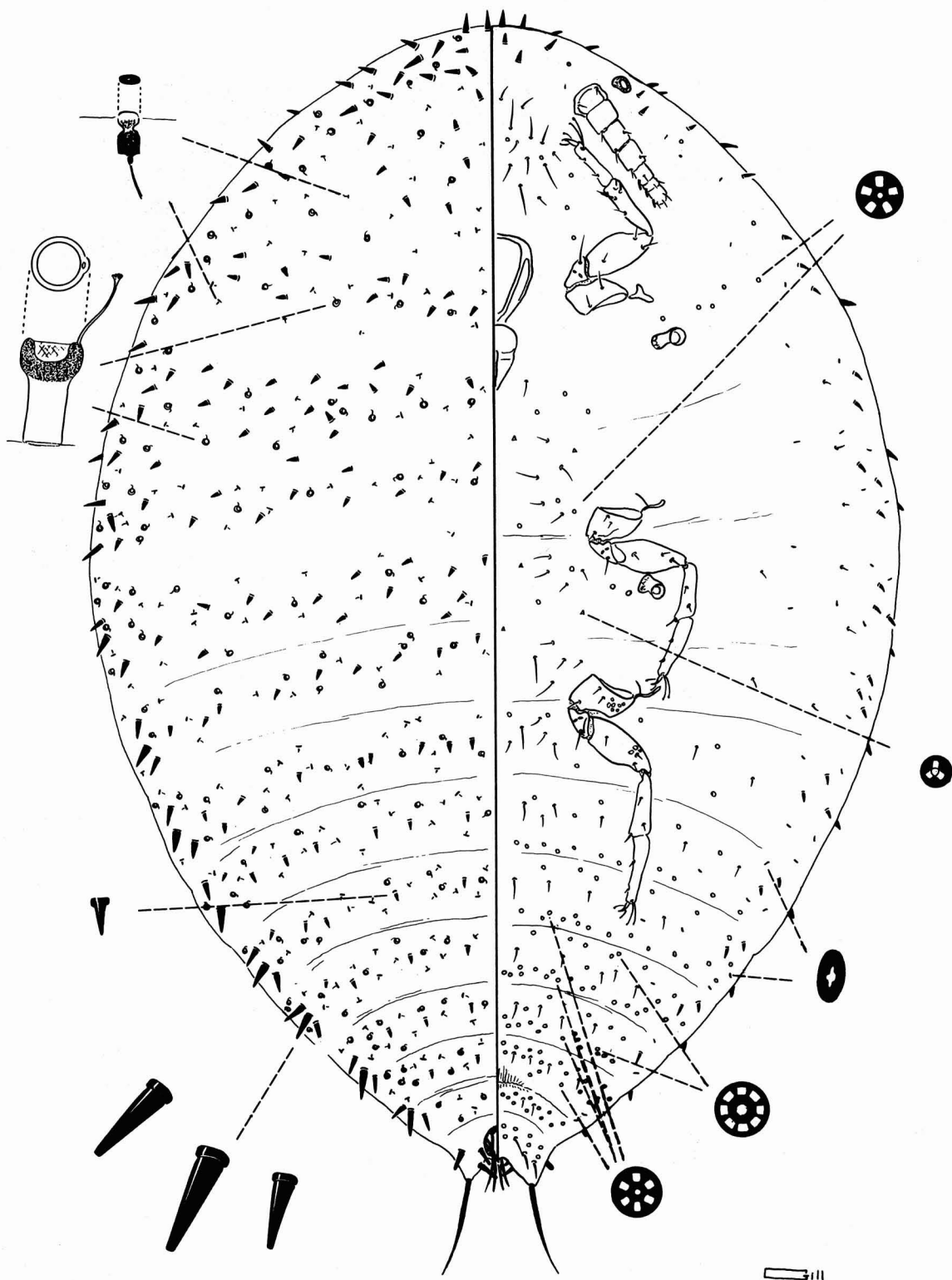


Fig. 103: *Acanthococcus texanus* (King).

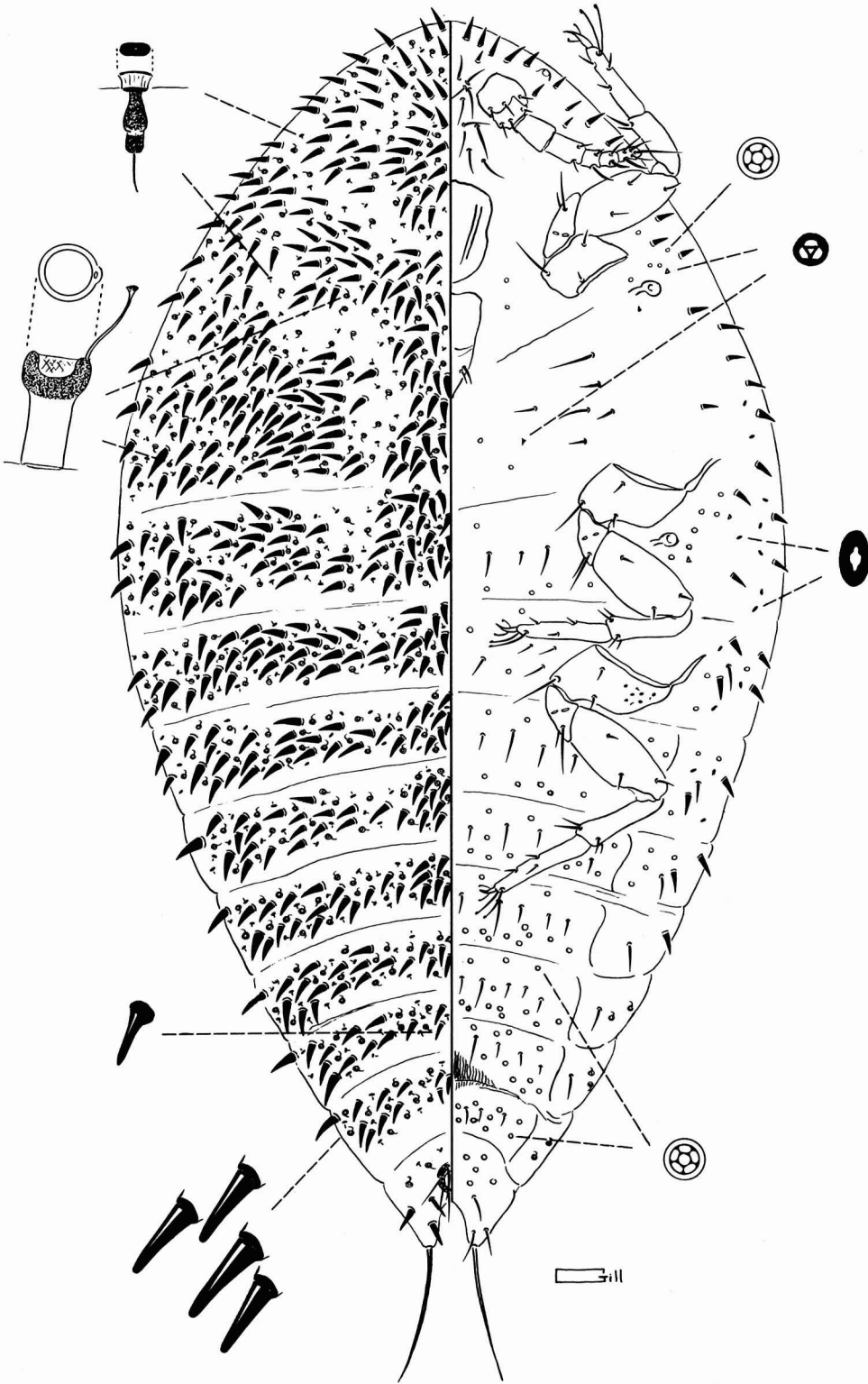


Fig. 104: *Acanthococcus tinsleyi* (Cockerell).

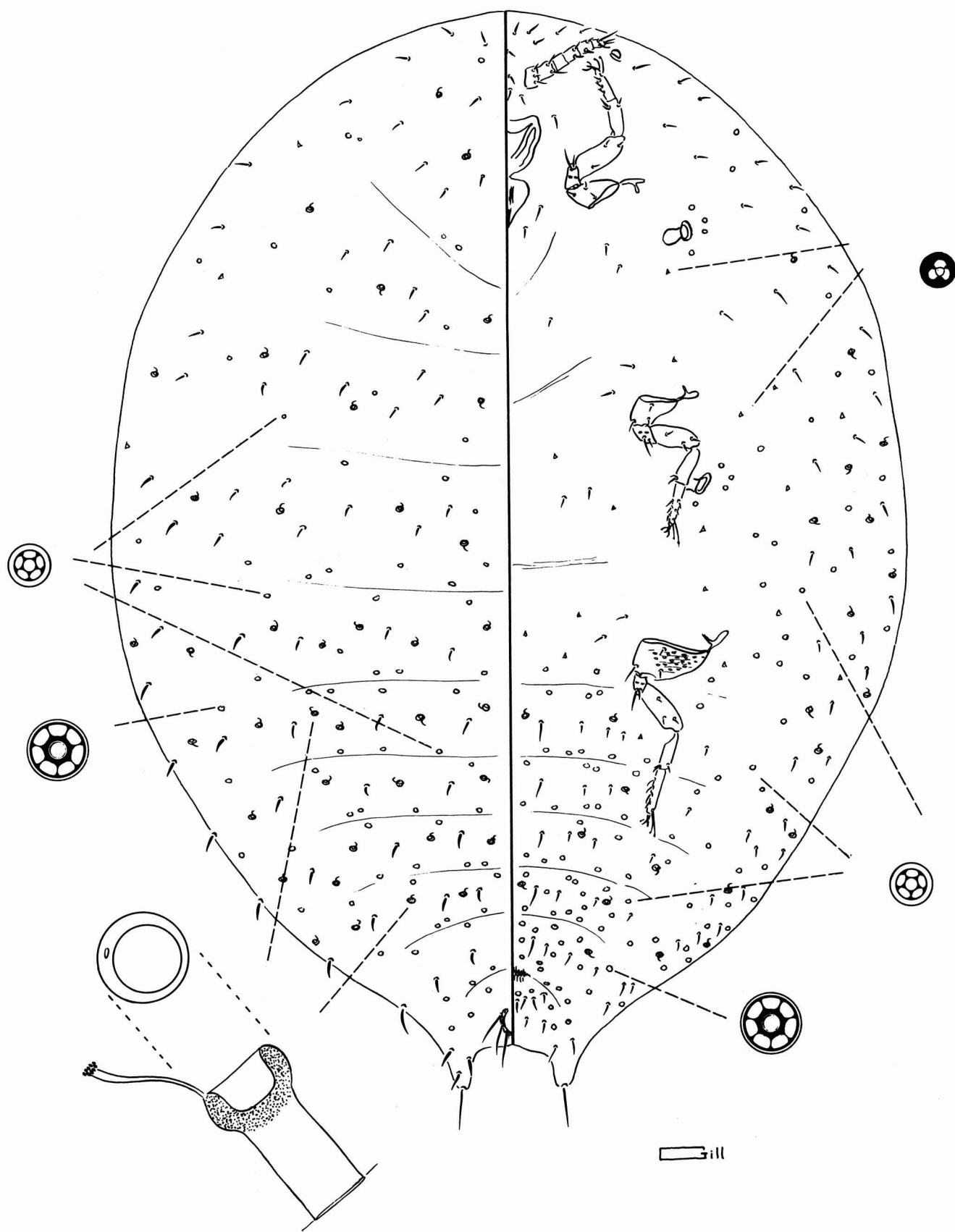


Fig. 105: *Atriplicia gallicolus* Cockerell and Rohwer.

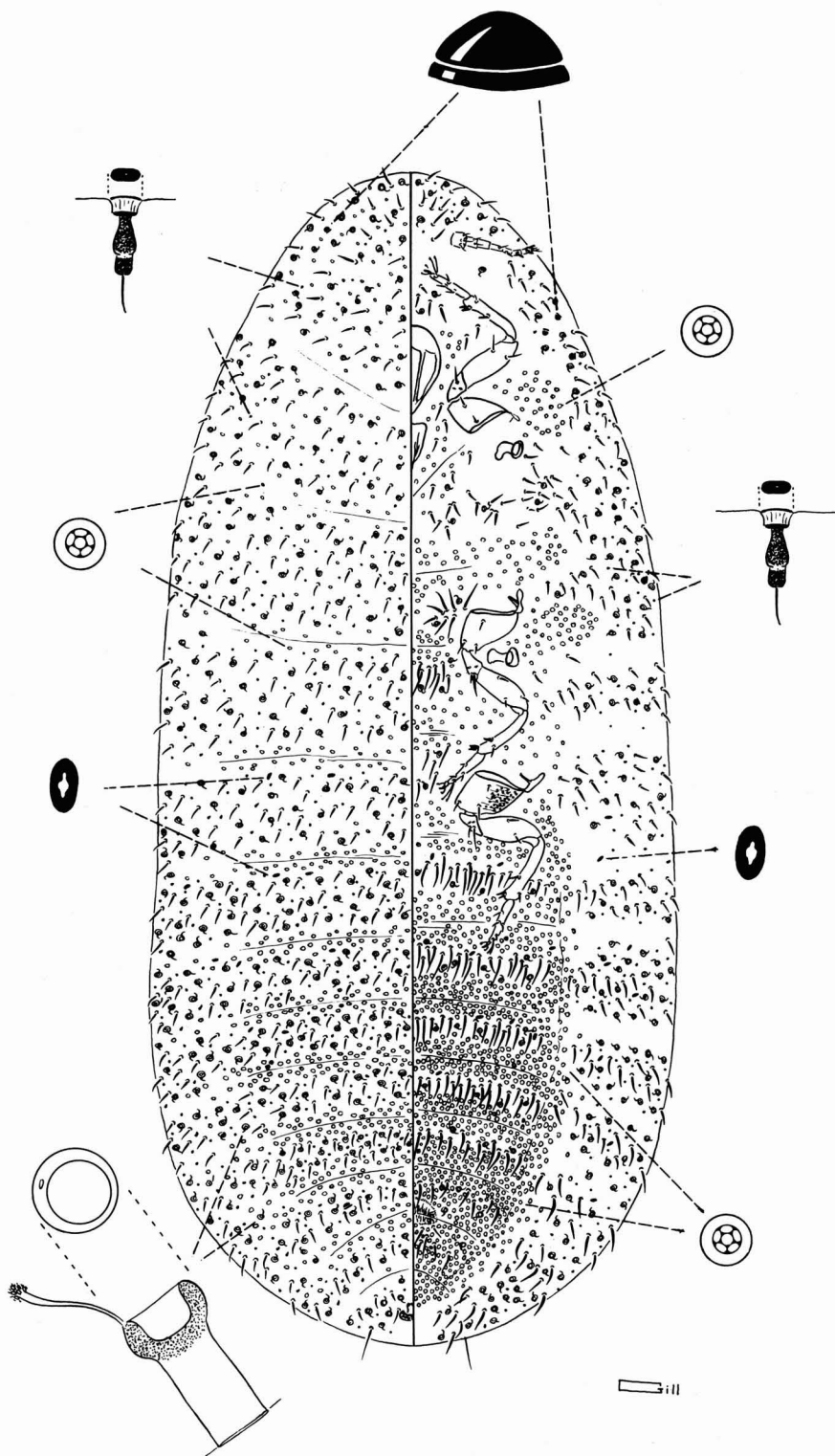


Fig. 106: *Cornoculus densus* Miller.

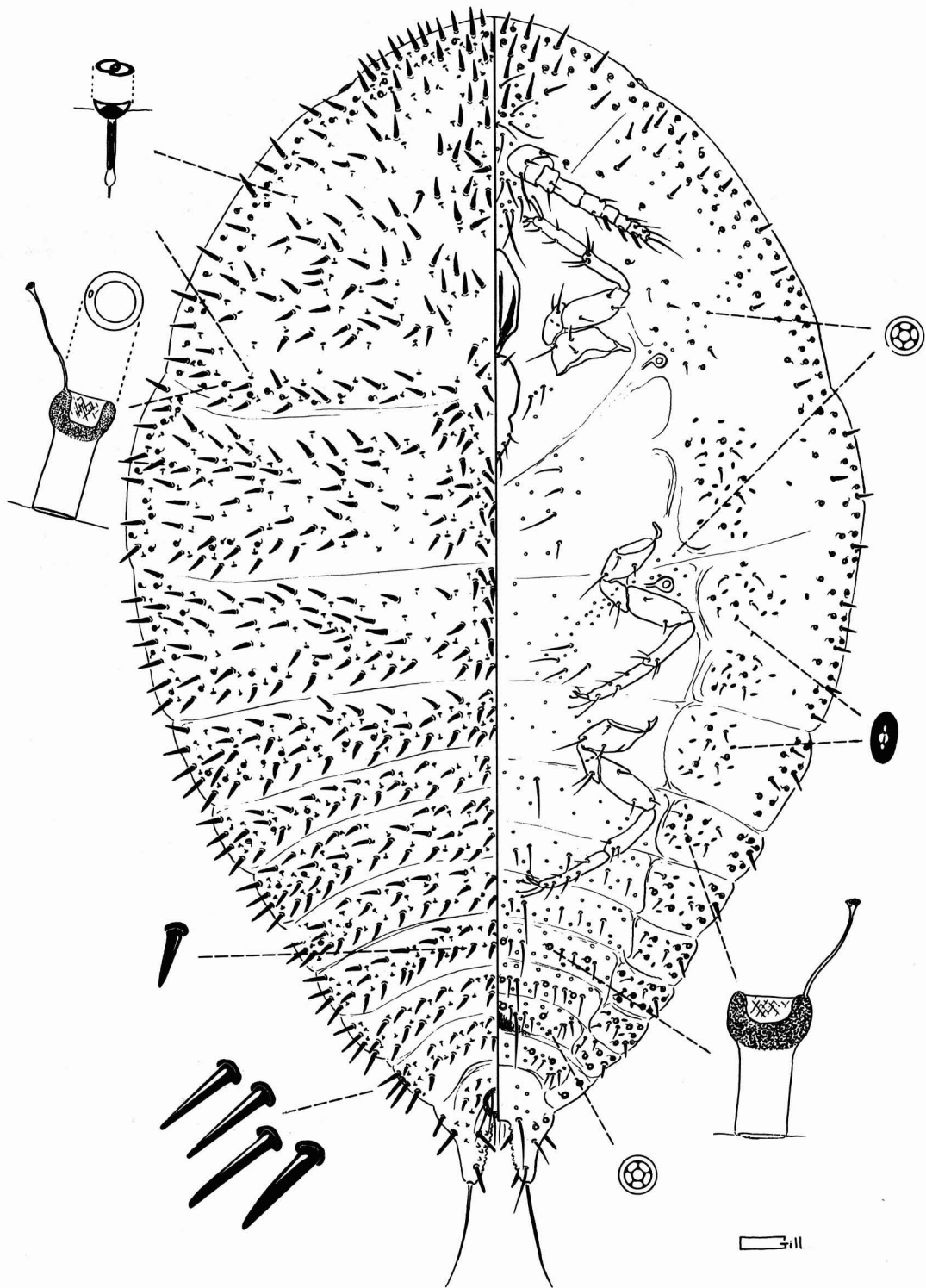


Fig. 107: *Gossyparia spuria* (Modeer).

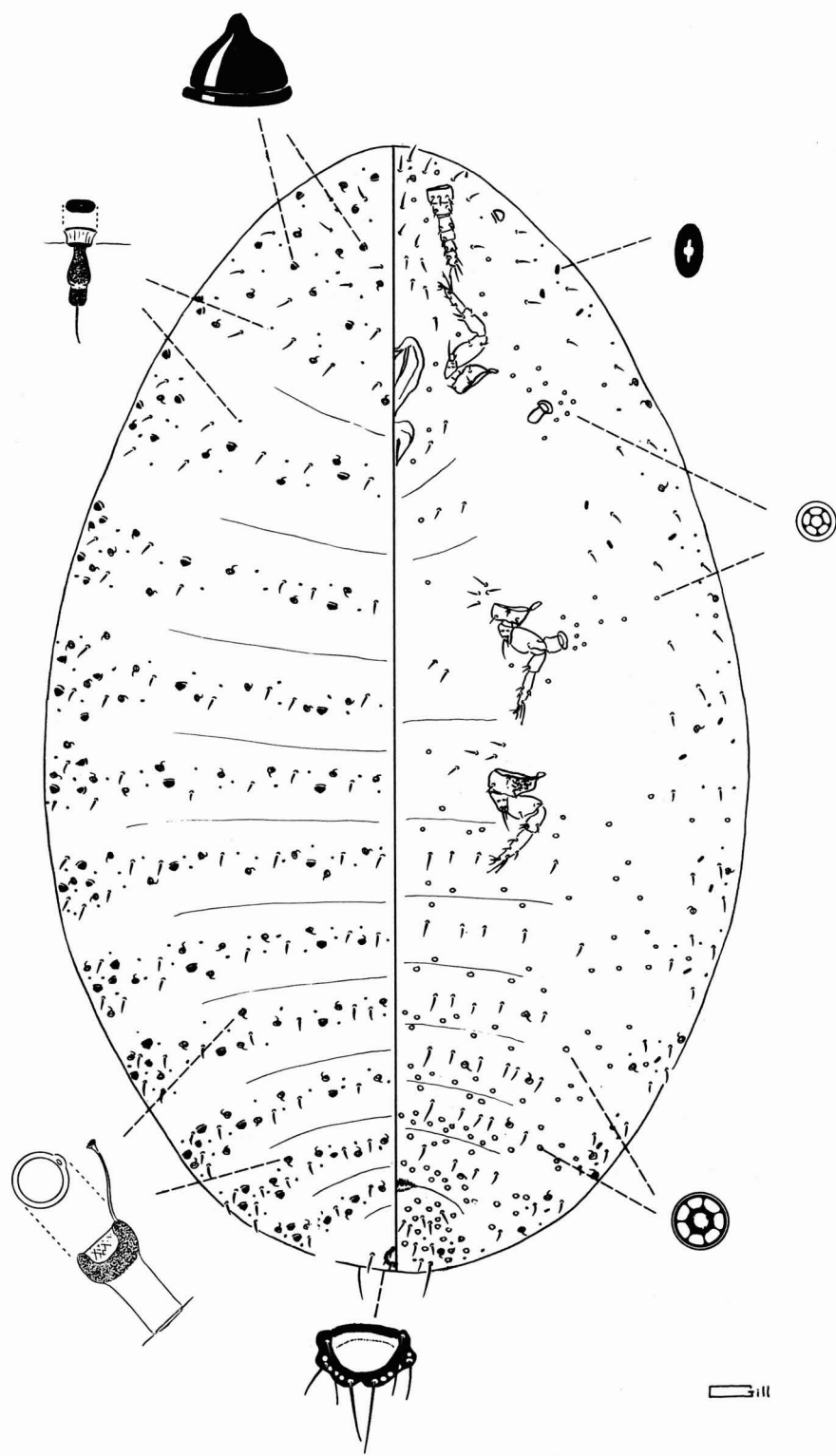


Fig. 108: *Oregmopyga eriogoni* Miller.

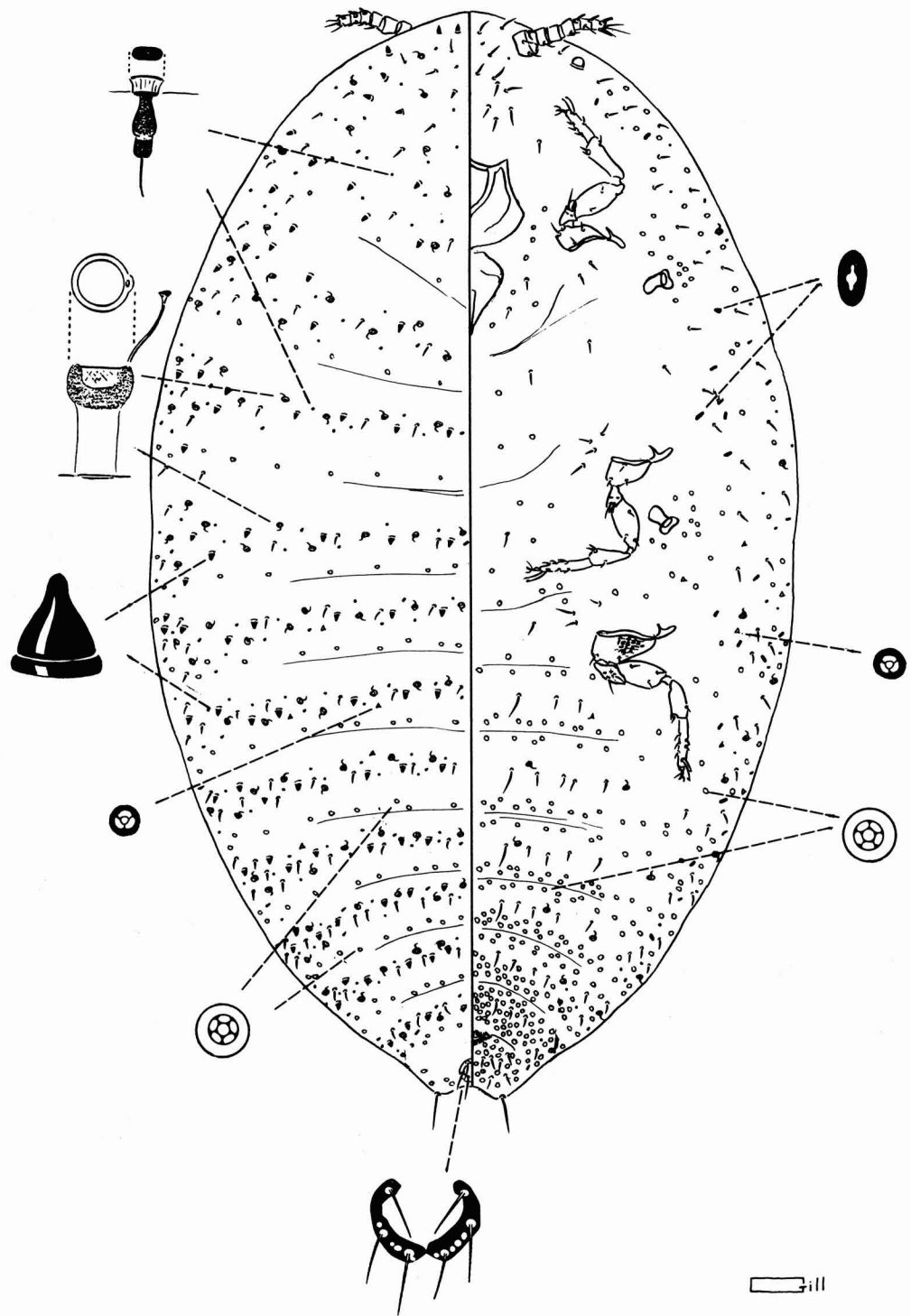


Fig. 109: *Oregmopyga johnsoni* Miller.

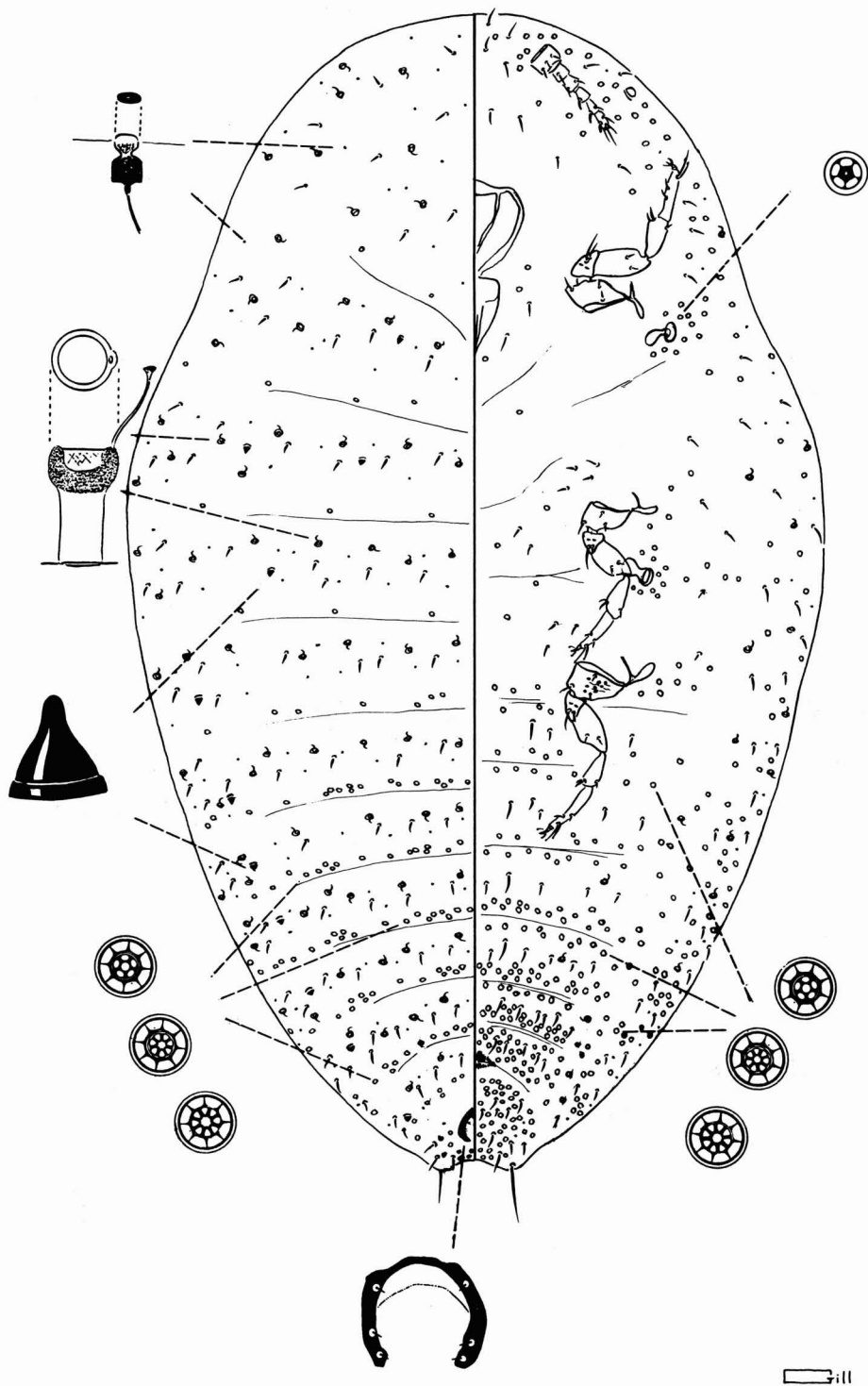


Fig. 110: *Oregmomyza neglecta* (Cockerell).

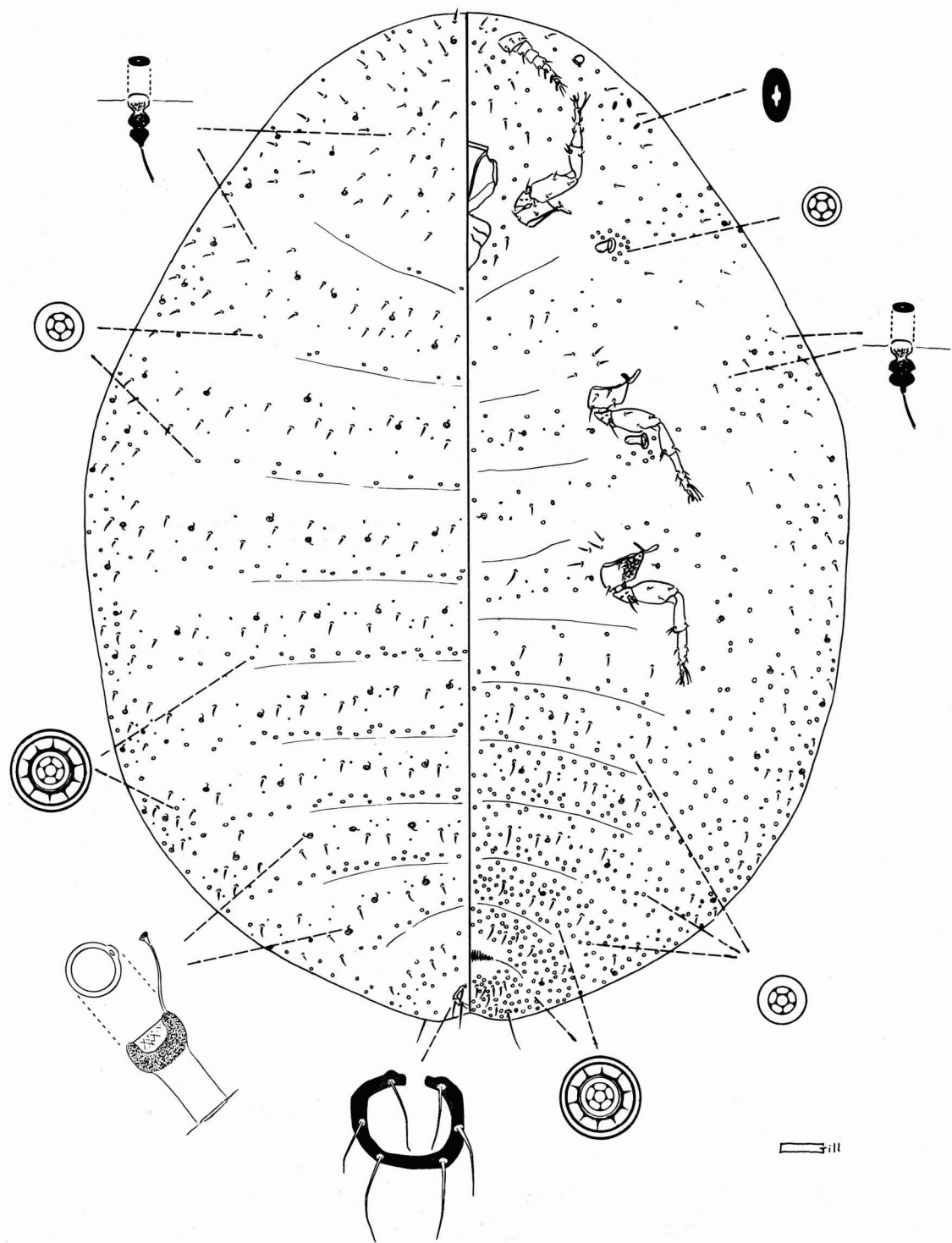


Fig. 111: *Oregmopyga sanguinea* Miller.

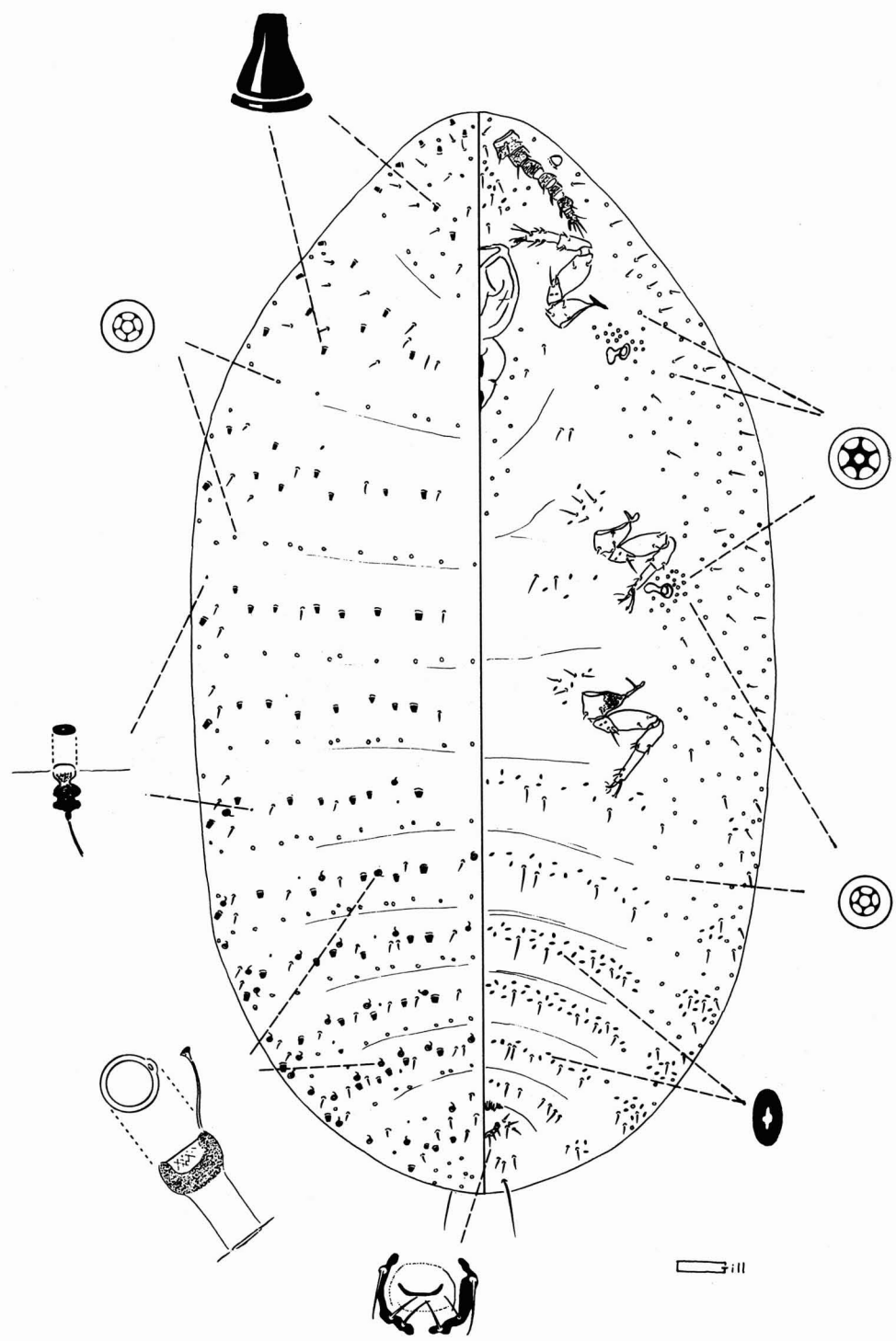


Fig. 112: *Ovaticoccus agavium* (Douglas).

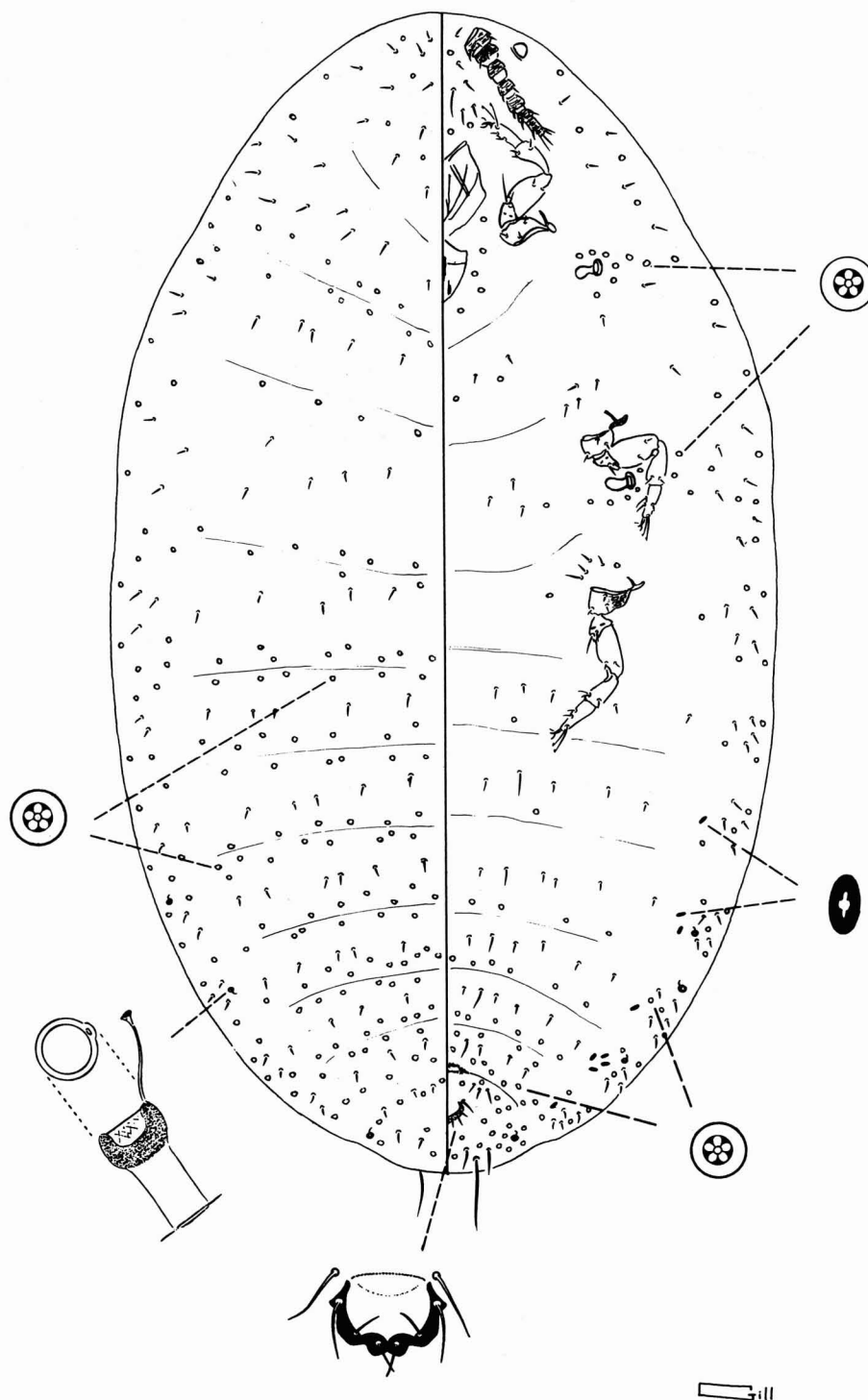


Fig. 113: *Ovaticoccus californicus* McKenzie.

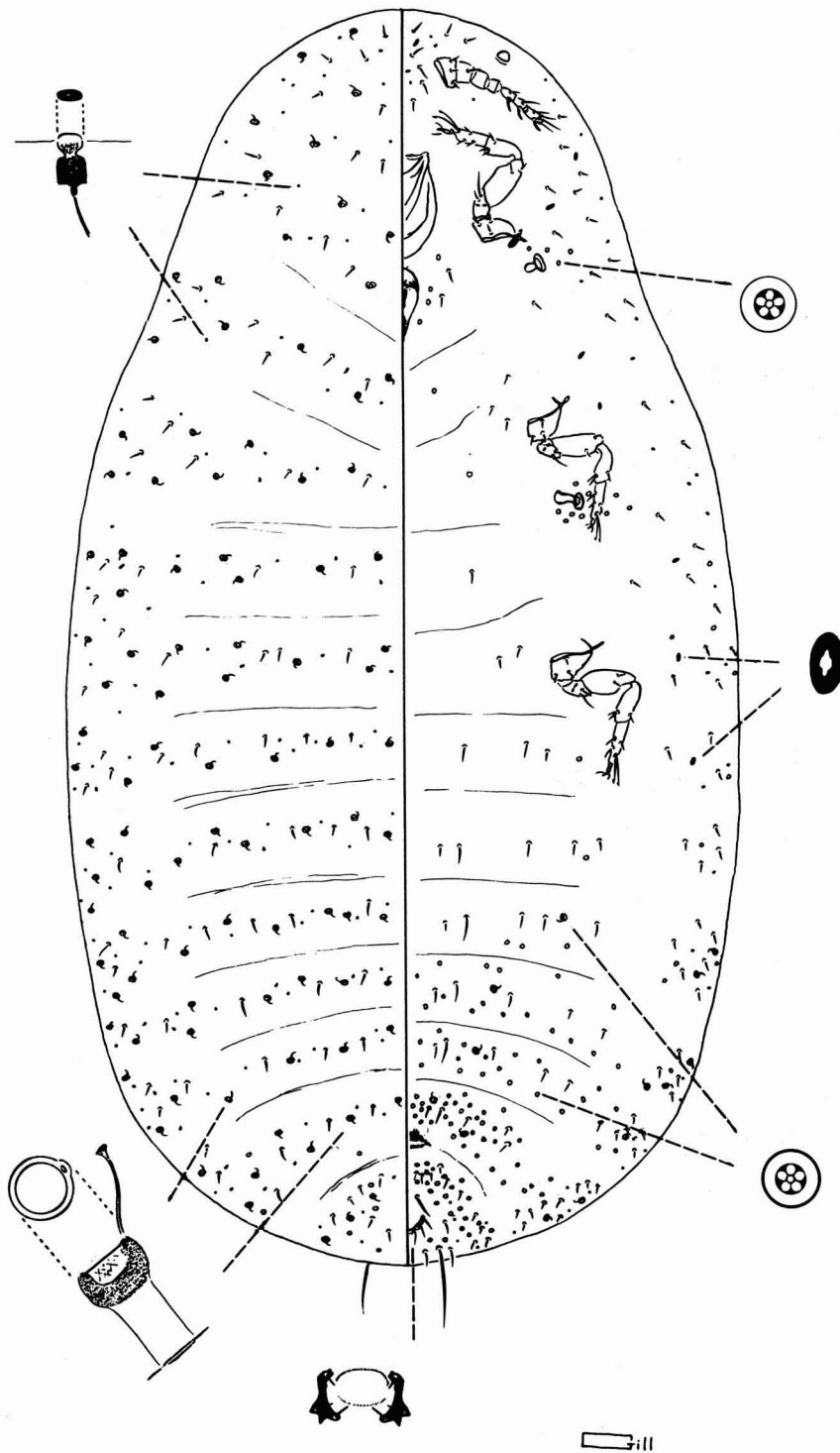


Fig. 114: *Ovaticoccus mackenziei* Miller.

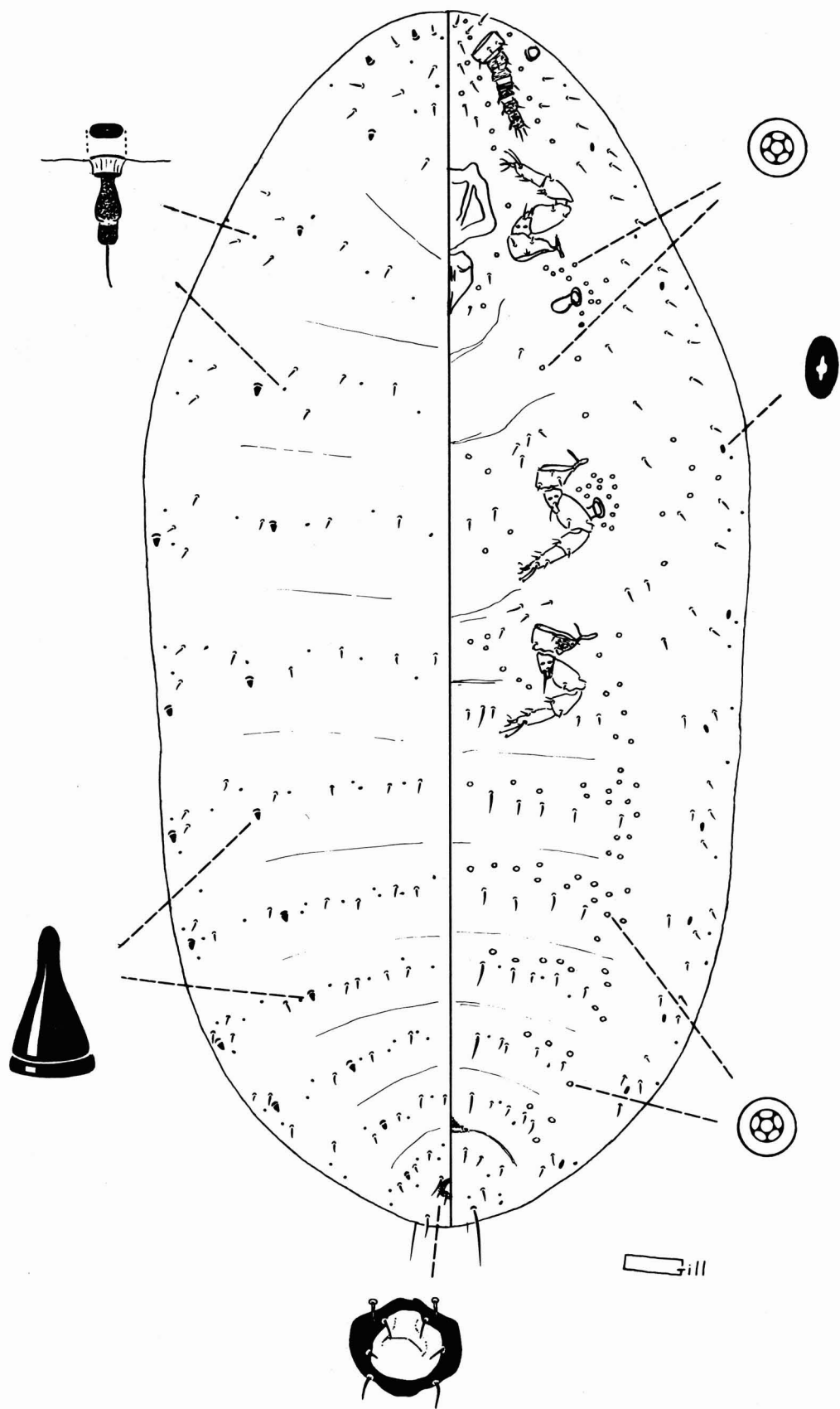


Fig. 115: *Ovaticoccus parkerorum* Miller.

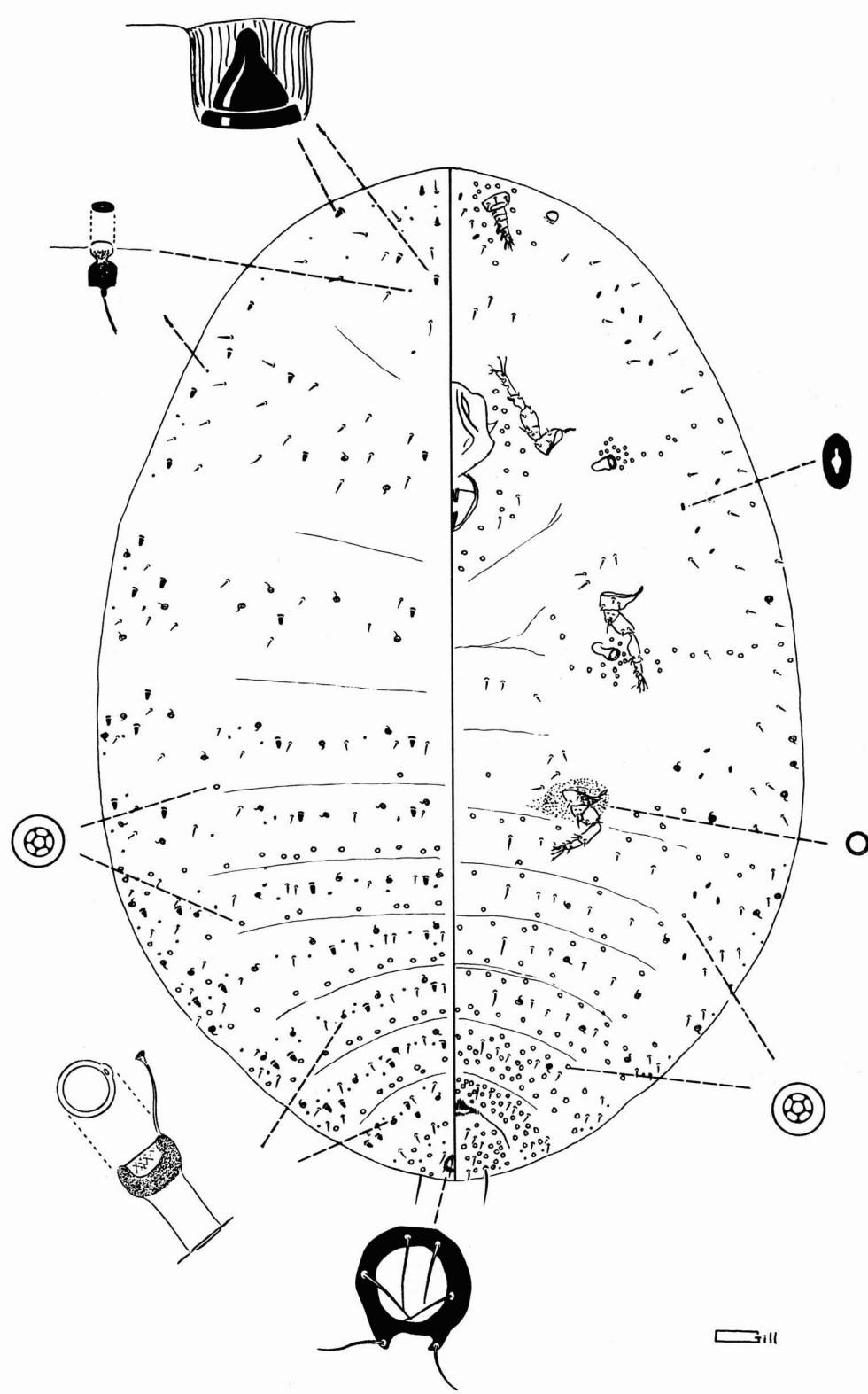


Fig. 116: *Ovaticoccus salviae* Miller.

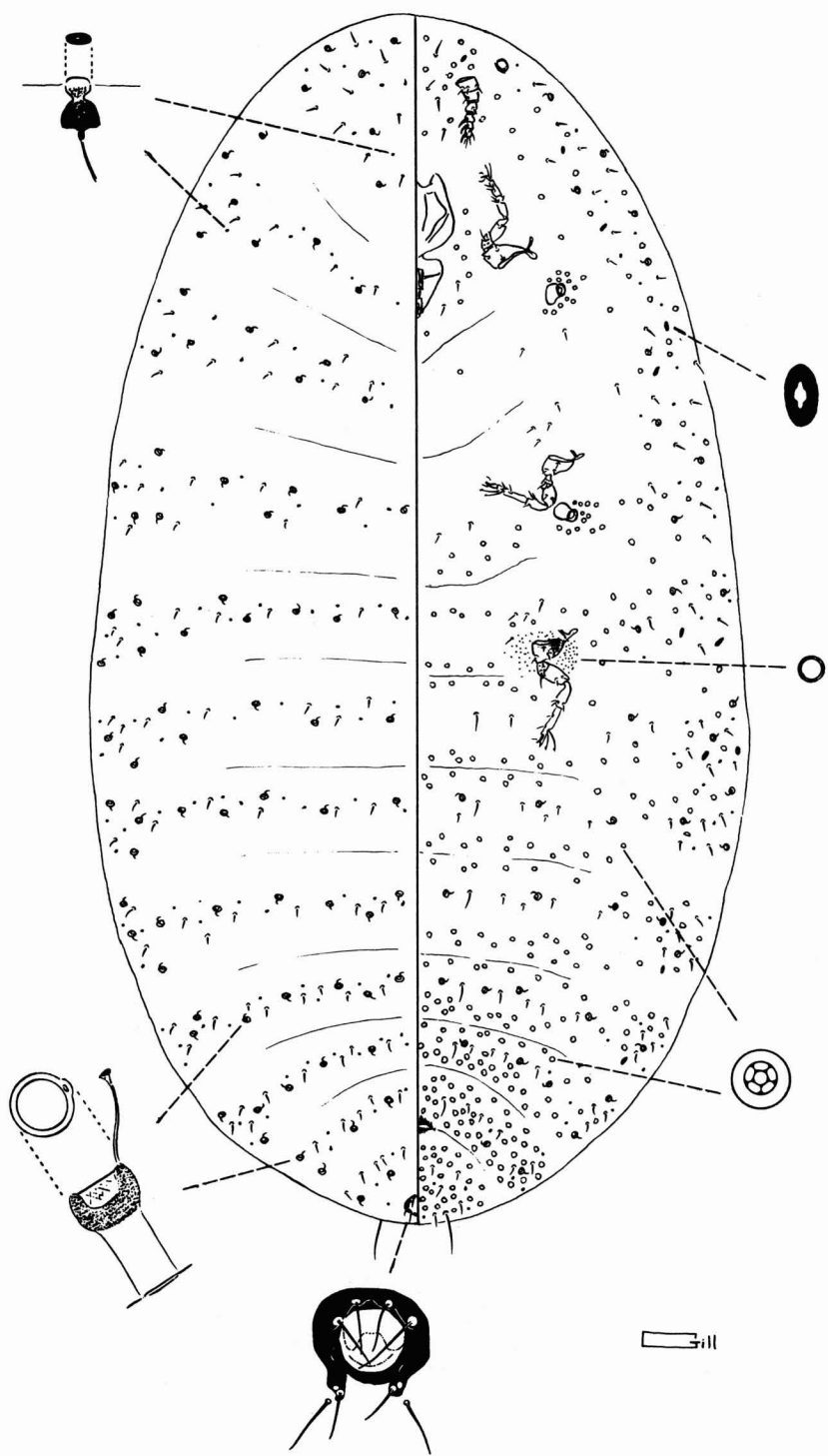


Fig. 117: *Ovaticoccus senarius* McKenzie.

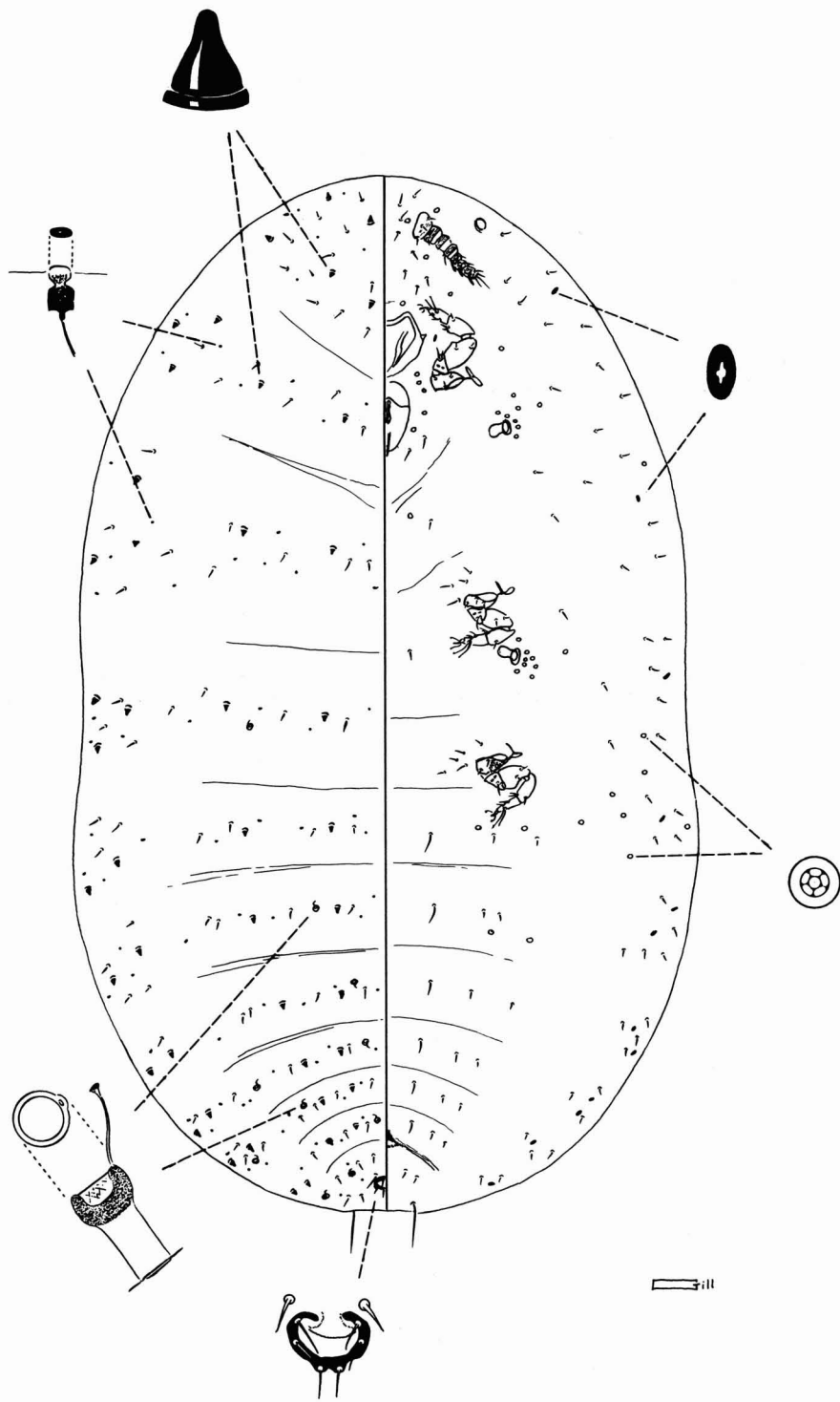


Fig. 118: *Ovaticoccus variabilis* Miller.

FAMILY PHOENICOCOCCIDAE

palm scales or lubberly coccids

Color Plate 108

A small family containing only one species presently found in the United States. The family was at one time included in the Diaspidine subfamily *Phoenicococcinae* but recently various authorities have felt that the subfamily should be elevated to family rank. It is listed as the family *Phoenicococcidae* by Brown & McKenzie (1962). The placement of this family is still not resolved however, because several genera previously included in the subfamily *Phoenicococcinae* are now included under the genus *Colobopyga* in the family *Halimococcidae* or under *Ancepaspis* in the *Diaspididae*. Essig (1958) lists it in the *Cylindrococcinae*. It may be some time before the true relationships of these unusual scales are understood. For further information see Brown & McKenzie (1962), and Brown (1965). Since only one introduced species in this group is known from California and North America north of Mexico, and since the limits of the family itself are rather uncertain, the characteristics of the family as a whole cannot be discussed here. See the discussion of *Phoenicococcus marlatti* which follows and the work of Stickney (1934).

References:

Brown, S. W., 1965: *Hilgardia* 36(5):189-294.

Brown, S. W., and H. L. McKenzie, 1962: *Hilgardia* 33(4):133-171.

Essig, E. O., 1958: *Insects and Mites of Western North America*. The MacMillan Co., New York. 1050 pp.

Stickney, F. S., 1934: U. S. Dep. Agric. Tech. Bull. 404:1-162.

CALIFORNIA SPECIES OF PHOENICOCOCCIDAE

Genus *Phoenicococcus* Cockerell, 1899

Number of World species: 1.

Number of U.S. species: 1.

Key to the North American species in the family: Ferris 1942 (1937-1942).

Phoenicococcus marlatti Cockerell, 1899 red date scale (ESA approved)

Fig. 119, Color Plate 108

Other Common Names:

red date-palm scale, Marlatt scale.

Synonymy:

Sphaerococcus draperi Newstead.

Field Characteristics: Adult females 1.0 to 1.5 mm in diameter, irregularly spherical, dark red to brown, partly surrounded by a nest-like amorphous mass of white wax. Males prod-

uct a loose, elongate, white cocoon.

Biology: Has continuous overlapping yearly generations. Usually found on white tissue at the frond bases under the fiber bands near the trunk. In heavy infestations and in cooler climates may also be found along the length of the fronds at the leaf bases and in the leaf folds along the midrib. In some cases may be found

on the exposed superficial roots. For more information see Borden (1921), Stickney et al., (1950) and Essig (1958).

Similar Species: None in the United States.

Hosts: Restricted primarily to palms, especially in the genus *Phoenix*, and to *Pandanus*.

Economic Importance: A minor pest of commercial dates according to Boyden (1941) and Stickney et al., (1950). Other authors such as Borden (1921) and Essig (1958) list it as a rather serious pest of dates under certain conditions. Present in commercial date plantings in the Coachella Valley of Riverside County, but not considered an economically important pest. Does not have many natural enemies, although Borden (1921) lists a Cucujid beetle which attacks the heavier populations. Stickney et al., (1950) list several other predators.

Distribution: Date growing areas of Riverside and Imperial Counties; collected occasionally from other Southern and Central California locations on ornamental palms. Also occurs in Arizona and Texas. Introduced into the United States from North Africa in 1890.

Diagnosis: Host plant preference and physical appearance aid in identification. Structurally resembles an armored scale but lacks pygidium. Morphology of adult female is illustrated here and in McKenzie (1956); morphology of all stages is illustrated in Morrison (1921) and Stickney (1934).

Borden, A. D., 1921: J. Agric. Res. 21(9):659-676.

Boyden, B. L., 1941: U. S. Dep. Agric. Misc. Publ. 433:1-62.

Essig, E. O., 1958: Insects and mites of western North America. The MacMillan Co., N.Y. 1050 pp.

McKenzie, H. L., 1956: The Armored Scale Insects of California. Univ. Calif. Press, Berkeley. 209 pp.

Morrison, H., 1921: J. Agric. Res. 11(9):669-676.

Stickney, F. S., 1934: U. S. Dep. Agric. Tech. Bull. 404:1-162.

Stickney, F. S., D. F. Barnes and P. S. Simmons, 1950: U. S. Dep. Agric. Circ. 846:1-57.

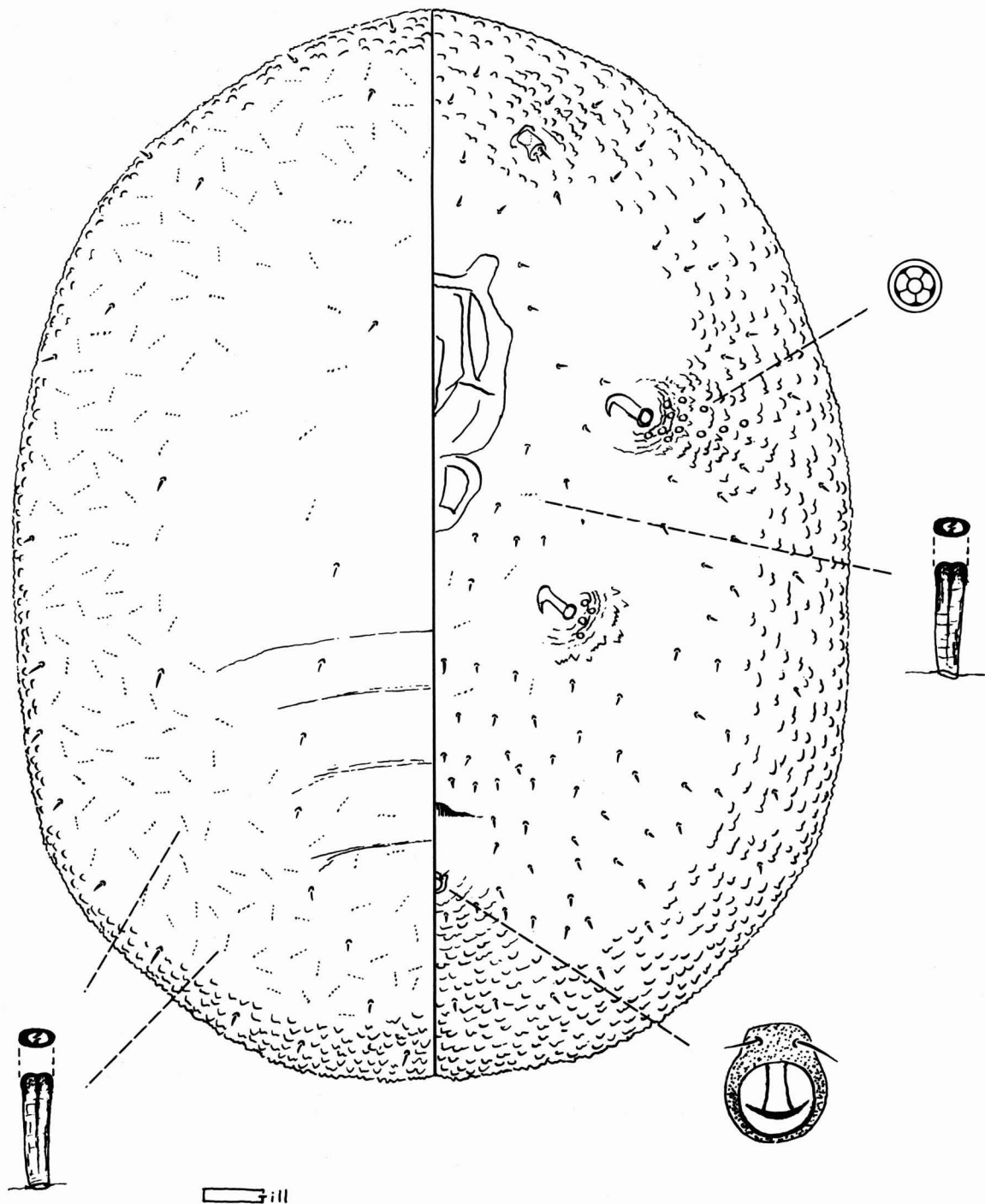


Fig. 119: *Phoenicococcus marlatti* Cockerell.

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COLLECTION DATA FOR MORPHOLOGICAL FIGURES

18. *Desmococcus captivus*, nr. Mono Lake, Mono Co. California, VIII-14-39, ex *Pinus monophylla*, G. Ferris collector.
19. *Icerya purchasi*, San Francisco, San Francisco Co. California, III-27-68, ex *Pittosporum undulatum*, M. Stufflebeam collector.
20. *Kuwania quercus*, 2.5 mi. E. Montecello on Hwy 128, Yolo Co. California, VII-21-65, ex *Quercus douglasii*, T. Kono and R. Wilkey collectors.
21. *Margarodes meridionalis*, Tempe, Maricopa Co. Arizona, collected IV-67, reared VII-19-67, ex "tifgreen" Bermuda grass, A. DeLellis collector.
- 22a. *Matsucoccus acalyptus* (adult), Kennedy Meadows, Tulare Co. California, V-11-69, ex *Pinus edulis*, L. Myers collector.
- 22b. *Matsucoccus acalyptus* (cyst), Hot Springs, Sierra Co. New Mexico, IV-5-48, ex piñon pine, J. Eyer collector.
23. *Matsucoccus bisetosus* (adult), quarantine at Mt. Shasta California from Washington, II-25-78, ex pine, D. Sage collector.
24. *Matsucoccus californicus*, Burgess Spring Lassen Co. California, VIII-20-78, ex *Pinus ponderosa*, C. Ray and R. Gill collectors.
- 25a. *Matsucoccus fasciculensis* (adult), Black Butte, Mt. Shasta, Siskiyou Co. California, V-68, ex *Pinus ponderosa*, R. Allen collector.
- 25b. *Matsucoccus fasciculensis* (cyst), South Lake Tahoe, El Dorado Co. California, XI-6-68, ex *Pinus murrayana*, R. Wilkey collector.
26. *Matsucoccus monophyllae*, Chuchupate Ranger Station, Los Padres National Forest, Kern Co. California, XI-5-38, ex *Pinus monophylla*, J. Patterson and S. Carlson collectors.
27. *Matsucoccus paucicatrices*, Challenge, Butte Co. California, III-9-67, ex *Pinus lambertiana*, R. Hunt collector.
28. *Matsucoccus secretus*, Monument, El Paso Co. Colorado, Summer 1935, ex *Pinus ponderosa*, C. Hartley collector.
29. *Pityococcus deleoni*, Mt. Laguna, San Diego Co. California, III-19-41, ex *Pinus quadrifolia*, D. DeLeon collector.
30. *Pityococcus ferrisi* (adult), 12 mi. NE. Big Pine, Bristle Cone Monument, Inyo Co. California, IX-14-69, ex *Pinus monophylla*, T. Kono collector.
- 30a. *Pityococcus ferrisi* (cyst), Denver, Denver Co. Colorado, XI-68, ex *Pinus edulis*, W. Brewer collector.
31. *Steatococcus townsendi*, Hackberry Mtn., San Bernardino Co., California, VII-23-70, ex *Ambrosia ericentra*, R. Goeden and D. Ricker collectors.
32. *Stomacoccus platani*, Sacramento, Sacramento Co. California, III-20-67, ex *Platanus* sp., A. Boisonou collector.
- 33a. *Xylococcus betulae* (adult), Salyer, Trinity Co. California, IV-13-62, ex *Alnus* sp., T. Haig collector.
- 33b,c. *Xylococcus betulae* (cyst), Avila Beach, San Luis Obispo Co. California, III-16-61, ex *Castanea* sp., R. Drake et al collectors.
34. *Xylococcus macrocarpae* (adult /), El Portal, San Mateo Co. California, V-8-63, ex incense cedar, D. Dilley collector.
- 35a. *Xylococcus macrocarpae* (1st stage nymph, "crawler"), Blodgett Experimental Forest, El Dorado Co., California, V-27-85, ex incense cedar, S. Tait collector.
- 35b. *Xylococcus macrocarpae* (settled crawler), Blodgett Experimental Forest, El Dorado Co. California, V-27-85, ex incense cedar, S. Tait collector.
- 35c. *Xylococcus macrocarpae* (2nd stage / nymph), Butte Co. California, III-85, ex incense cedar, collector unknown.
36. *Xylococcus macrocarpae* (3rd stage / nymph), Julian, San Diego Co. California, V-4-70, ex native cedar, K. Sims collector.
- 37a. *Xylococcus macrocarpae* (2nd stage ? nymph), Murphy's, Calaveras Co. California, XI-6-58, ex incense cedar, J. Joos collector.
- 37b. *Xylococcus macrocarpae* (prepupal ? nymph), Blodgett Experimental Forest, El Dorado Co., California, date not available, ex incense cedar, S. Tait collector.
38. *Xylococcus macrocarpae* (pupal ? nymph), Pleasanton, Alameda Co. California, V-31-77, ex *Cedrus* sp., J. Lonegran collector.
39. *Xylococcus macrocarpae* (adult ?), Butte Co. California, III-85, ex incense cedar, collector unknown.
40. *Xylococcus quercus*, (adult ?), Moraga, San Joaquin Co. California, IX-30-81, ex *Quercus lobata*, K. Brown and R. Gill collectors.
41. *Arctorthezia occidentalis*, Burnt Ranch, Trinity Co. California, IV-18-74, ex moss, T. Haig collector.
42. *Arctorthezia pseudoccidentalis*, Goat Rock, Sonoma Coast State Park, Sonoma Co. California, X-10-67, ex *Artemisia* sp., R. Wilkey collector.
43. *Orthezia annae*, Supai, Coconino Co. Arizona, IX-18-69, ex *Pluchea* sp., R. Allen collector.
44. *Orthezia artemisiae*, 5 mi. W. Likely, Modoc Co. California, VI-23-62, ex *Artemisia tridentata*, T. Haig collector.
45. *Orthezia insignis*, Bosor, Java, Indonesia, XII-27-74, ex *Coleus* sp., G. Brady collector.
46. *Orthezia newcomberi*, North Sacramento, Sacra-

SCALE INSECTS OF CALIFORNIA

COLLECTION DATA

- mento Co. California, VI-6-63, ex. *Rubus* sp., M. Scribner and W. Wiard collectors.
47. *Orthezia sarcobati*, 1.3 mi. SE. Beatty, Nye Co. Nevada, VI-24-62, ex. *Sarcobatus vermiculatus*, T. Fuller collector.
 48. *Tachardiella ferrisi*, Temecula, Riverside Co. California, VIII-24-71, ex *Adenostoma sparsifolia*, R. Gill collector.
 49. *Tachardiella glomerella*, Boulevard, San Diego Co. California, IX-3-71, ex *Adenostoma fasciculata*, G. Reese collector.
 50. *Tachardiella larreae*, Holtville, Imperial Co. California, I-25-72, ex *Larrea divaricata*, R. Gill collector.
 51. *Tachardiella pustulans*, Niland, Imperial Co. California, III-7-66, ex *Hymenoclea salsola*?, R. Flock collector.
 52. *Asterolecanium agavis*, quarantine from Mexico at El Paso, Texas, III-18-51, ex cactus, W. Vertrees collector.
 53. *Asterolecanium arabidis*, Sacramento, Sacramento Co., California, XI-10-75, ex *Pittosporum* sp., J. Chesi collector.
 54. *Asterolecanium grandicolum*, El Centro, Imperial Co., IV-16-70, ex *Yucca glauca*, E. Paddock collector.
 55. *Asterolecanium minus*, Graton, Sonoma Co., California, X-13-74, ex *Quercus* sp., D. Loukonen collector.
 56. *Asterolecanium quercicola*, Sacramento, Sacramento Co., California, VII-31-62, ex *Quercus coccinea*, R. Snelling collector.
 57. *Asterolecanium stentae*, Jamul, San Diego Co. California, X-17-88, ex *Euphorbia* sp., J. Kenyon collector.
 58. *Asterolecanium variolosum*, Windsor, Sonoma Co., California, XI-27-37, ex English white oak, O. Bremner collector.
 59. *Bambusaspis bambusae*, Escondido, San Diego Co., California, XI-14-75, ex giant bamboo, Gordon and Geising collectors.
 60. *Mycetococcus ehrhorni*, Fallbrook, San Diego Co., California, X-10-67, ex *Quercus* sp., R. Rinder and M. Hess collectors.
 61. *Pollinia pollini*, Asti, Sonoma Co., California, X-20-76, ex olive, R. Gill and J. Chesi collectors.
 62. *Lecanodiaspis prosopidis*, Arivaca, Pima Co. California, IX-25-43, ex *Prosopis juliflora*, J. Bache-Wiig collector.
 63. *Lecanodiaspis rufescens*, Lancaster, Los Angeles Co. California, IX-30-75, host unknown, D. Poore and A. Gilbert collectors.
 64. *Lecanodiaspis thamnasmae*, Ocotillo, Imperial Co. California, IV-27-72, ex *Thamnosma montana*, E. Paddock et al collectors.
 65. *Cerococcus quercus*, Descanso, San Diego Co., California, III-15-68, ex *Quercus englemanni*, G. Schwegel and W. Radcliffe collectors.
 66. *Aclerda californica*, San Jose, Santa Clara Co., California, XI-14-46, ex quack grass?, G. Prole and T. Gallion collectors.
 67. *Aclerda tokionis*, Riverton, Burlington Co., New Jersey, XII-9-54, ex bamboo, A. Soreci collector.
 68. *Allokermes branigani*, Paragon (Bath) Mine, Foresthill, Placer Co., California, VI-1-76, ex *Quercus chrysolepis*, R. Gill and J. Chesi collectors.
 69. *Allokermes essigi*, Carmichael, Sacramento Co., California, X-19-77, ex *Quercus wislizenii*, R. Gill collector.
 70. *Allokermes ferrisi*, 7 mi. E. Superior, Arizona, IX-1-69, ex *Quercus emoryi*, P. Min and D. Carver collectors.
 71. *Allokermes galliformis*, Arlington West Virginia, VI-28-77, ex *Quercus laurifolia*, Mrs. F. Halley collector.
 72. *Allokermes rattani*, Loma Prieta Mtn, Santa Clara Co. California, VII-16-22, ex *Chrysolepis chrysophylla*, G.F. Ferris collector.
 73. "*Eriococcus*" *gillettei*, Reno, Washoe Co. Nevada, VI-30-72, ex *Juniperus* sp., R. Bechtel collector.
 74. *Kermes nudus*, Earthquake Fault, Mammoth Lakes, Mono Co. California, VII-4-76, ex *Castenopsis sempervirens*, R. and R. Gill collectors.
 75. *Kermes rimarum*, Beulah, Pueblo Co. New Mexico, VII-15-47, ex oak, G. Ferris collector.
 76. *Kermes shastensis*, Shasta, Siskiyou Co., California, V-19-76, ex *Quercus chrysolepis*, R. Gill collector.
 77. *Dactylopius confusus*, South Laguna, Orange Co. California, V-13-76, ex *Opuntia* sp., J. Steinweden collector.
 78. *Dactylopius opuntiae*, San Diego, San Diego Co. California, II-26-75, ex *Opuntia* sp., Brown and Gionfriddo collectors.
 79. *Dactylopius tomentosus*, Julian, San Diego Co. California, IV-18-63, ex cactus, N. Buskirk collector.
 80. *Acanthococcus adenostomae*, 14 mi. W. Winters, Napa Co. California, III-5-68, ex *Adenostoma fasciculatum*, R. Wilkey collector.
 81. *Acanthococcus araucariae*, San Ysidro, San Diego Co. California, V-30-74, ex star pine, Knott and Geising collectors.
 82. *Acanthococcus arctostaphyli*, Redding, Shasta Co., California, no date, ex *Arctostaphylos patula*?, R. Doane collector.
 83. *Acanthococcus azaleae*, Portland, Oregon, IV-24-74, ex *Rhododendron* sp., F. Larson and H. Nicholaison collectors.
 84. *Acanthococcus barri*, 2 mi. E. Tonapah, Nevada, VII-7-68, ex *Atriplex* sp., R. Miller and R. Denno collectors (illustration courtesy D.R. Miller).
 85. "*Eriococcus*" *borealis*, Camp Curry, Yosemite National Park California, VI-14-65, ex *Salix* sp., R. Wilkey collector.

86. *Acanthococcus coccineus*, Lodi, San Joaquin Co. California, XI-13-72, ex *Mammillaria* sp., J. Gianelli collector.
87. *Acanthococcus cryptus*, 7 mi. NE. Lordsburg, Hidalgo Co. New Mexico, IX-5-68, ex *Gutierrezia* sp., D. Miller and J. Lauck collectors.
88. *Acanthococcus diaboli*, Lancaster, Los Angeles Co. California, IV-10-61, ex *Hordeum leporinum*, G. Beever collector.
89. *Acanthococcus dubius*, 3 mi. E. Big Pine, Inyo Co., California, V-22-69, ex *Dalea fremontii*, T. Haig collector.
90. *Acanthococcus epacrotichus*, 12 mi. NE. Olene, Klamath Co. Oregon, VIII-2-68, ex *Artemisia* sp., D. Miller and R. Denno collectors (illustration courtesy D.R. Miller).
91. *Acanthococcus eriogoni*, Dripping Springs Guard Station, Riverside Co. California, VII-22-71, ex *Croton californica*, R. Gill collector.
92. *Acanthococcus euphorbiae*, Warm Springs, Clark Co. Nevada, VII-24-74, ex *Suaeda* sp., R. Bechtel and D. Zoller collectors.
93. *Acanthococcus froebae*, 5 mi. N. Baker, San Bernardino Co. California, IV-13-65, ex *Franseria* sp., D. R. Miller collector (illustration courtesy D.R. Miller).
94. *Acanthococcus hoyi*, 2 mi. W. Rodeo, Hidalgo Co. New Mexico, VIII-2-66, ex Graminae, D. Miller collector (illustration courtesy D.R. Miller).
95. *Acanthococcus insignis*, USSR, VII-27-58, ex *Hierocium pilosella*, collector unknown.
96. *Acanthococcus larreae*, Clark Co. Nevada, VI-22-56, ex *Larrea* sp. collector unknown.
97. *Acanthococcus mackenziei*, Valentine Cave, Siskiyou Co. California, VI-29-63, ex *Eriogonum latifolium*, D. Miller collector (illustration courtesy D. R. Miller).
98. *Acanthococcus macrobactrus*, Mt. Tamalpais, Marin Co. California, VI-23-68, ex *Arctostaphylos canescens*, D. Miller collector (illustration courtesy D. R. Miller).
99. *Acanthococcus palustris*, Almonte, Marin Co. California, XI-11-21, ex *Spartina filiosa*, C. Dodds collector (illustration courtesy D.R. Miller).
100. *Acanthococcus pittospori*, San Francisco, San Francisco Co. California, VIII-28-73, ex *Coprosma repens*, J. W. Cook collector.
101. *Acanthococcus quercus*, Santa Maria, Santa Barbara Co. California, X-22-62, ex *Quercus* sp., J. Betz collector.
102. *Acanthococcus salarius*, Bishop, Inyo Co. California, VIII-8-73, ex *Atriplex* sp., E. Paddock collector.
103. *Acanthococcus texanus*, Craters of the Moon State Park, Butte Co. Idaho, VIII-8-67, ex *Pteryxia terebinthina*, D. Miller and D. Horning collectors.
104. *Acanthococcus tinsleyi*, New Mexico, quarantine at Blythe Inspection Station, California, X-25-60, ex *Atriplex* sp., D. Dilley collector.
105. *Atriplicia gallicolus*, Deep Springs, Inyo Co. California, IX-27-28, ex terminal galls of *Atriplex* sp., G. Ferris collector.
106. *Cornoculus densus*, 6.9 mi. N. Lucerne Valley, San Bernardino Co., California, X-19-61, ex *Hilaria rigida*, T. Fuller collector.
107. *Gossyparia spuria*, Dinuba, Tulare Co. California, IV-5-76, ex elm, J. Akana et al collectors.
108. *Oregmomyza eriogoni*, 3 mi. N. Cajon Pass. San Bernardino Co. California, IV-17-65, ex *Eriogonum* sp., D. and J. Miller collectors.
109. *Oregmomyza johnsoni*, 3mi. E. Guida, Yolo Co. California, ex compositae, H. Court collector.
110. *Oregmomyza neglecta*, Quatal Canyon, Ventura Co. California, V-25-77, ex *Atriplex* sp., R. Hobza and R. Gill collectors.
111. *Oregmomyza sanguinea*, Thousand Palms Canyon, Riverside Co. California, IV-15-65, ex *Haplopappus acradenius*, D. and J. Miller collectors.
112. *Ovaticoccus agaviium*, Yucca Valley, San Bernardino Co. California, V-18-72, ex *Agave* sp., J. Lounsbury collector.
113. *Ovaticoccus californicus*, Lancaster, Los Angeles Co. California, IV-2-63, ex *Yucca brevifolia*, A. Cravens collector.
114. *Ovaticoccus mackenziei*, Morongo Valley, San Bernardino Co. California, II-26-63, ex *Ephedra californica*, H. McKenzie collector.
115. *Ovaticoccus parkerorum*, Panoche Pass, San Benito Co. California, I-23-65, ex *Haplopappus linearifolius*, D. Miller and F. Parker collectors.
116. *Ovaticoccus salviae*, Trabuco Canyon, Orange Co. California, III-28-64, ex *Salvia apiana*, D. Miller and J. Froebe collectors.
117. *Ovaticoccus senarius*, Borrego Springs, San Diego Co. California, II-25-63, ex *Franseria dumosa*, H. McKenzie collector.
118. *Ovaticoccus variabilis*, 6 mi. W. Greenfield, Monterey Co. California, ex *Artemisia californica*, D. Miller and F. Parker collectors.
119. *Phoenicococcus marlatti*, Marina Del Rey, Los Angeles Co., California, I-3-80, ex *Phoenix* sp., J. Humphreys collector.

COLLECTION DATA FOR COLOR PLATES

1. *Desmococcus captivus*, Westgard Pass, Inyo Co. California, VIII-17-91, ex. *Pinus monophylla*, R. Gill collector.
2. *Desmococcus captivus*, Westgard Pass, Inyo Co. California, VII-17-91, ex. *Pinus monophylla*, R. Gill collector.
3. *Icerya purchasi*, Stockton, San Joaquin Co. California, III-20-75, ex citrus, M. Croce collector.
4. *Icerya purchasi*, data not available.
5. *Icerya purchasi*, Grover City, Los Angeles Co. California, II-13-81, R. Hopkins collector.
6. *Kuwania quercus*, 4 mi. E. Monticello Dam, Yolo Co. California, VI-22-79, ex *Quercus douglasii*, T. Kono collector.
7. *Kuwania quercus*, 4 mi. E. Monticello Dam, Yolo Co. California, VI-22-79, ex *Quercus douglasii*, T. Kono collector.
8. *Margarodes heimalis*?, Teel Marsh, Mineral Co. Nevada, II-79, ex sand dunes, D. Giuliani collector.
9. *Margarodes meridionalis*, El Centro, Imperial Co. California, II-12-76, ex cactus roots, R. Flock collector.
10. *Matsucoccus acalyptus*, Westgard Pass, Inyo Co. California, VI-25-80, ex. *Pinus monophylla*, R. Gill collector.
11. *Matsucoccus acalyptus*, Westgard Pass, Inyo Co. California, VI-13-92, ex. *Pinus monophylla*, R. Gill collector.
12. *Matsucoccus fasciculensis*, No data available.
13. *Matsucoccus monophyllae*, Westgard Pass, Inyo Co. California, IV-2-92, ex. *Pinus monophylla*, R. Gill collector.
14. *Matsucoccus monophyllae*, Westgard Pass, Inyo Co. California, IV-13-92, ex. *Pinus monophylla*, R. Gill collector.
15. *Matsucoccus monophyllae*, Westgard Pass, Inyo Co. California, IV-15-92, ex. *Pinus monophylla*, R. Gill collector.
16. *Matsucoccus monophyllae*, Westgard Pass, Inyo Co. California, IV-15-92, ex. *Pinus monophylla*, R. Gill collector.
17. *Pityococcus deleoni*, 1 mi. E. Mt. Laguna, San Diego Co. California, II-6-82, ex *Pinus quadrifolia*, R. Gill collector.
18. *Pityococcus deleoni*, 1 mi. E. Mt. Laguna, San Diego Co. California, III-6-82, ex *Pinus quadrifolia*, R. Gill collector.
19. *Steatococcus* sp., Box Canyon Road, S. Interstate 5, Riverside Co. California, II-16-76, ex *Larrea* sp., W. Ewart collector.
20. *Steatococcus* sp., No data available.
21. *Stomacoccus platani*, Vacaville, Solano Co. California, IV-29-93, ex sycamore, M.J. Cody collector.
22. *Stomacoccus platani*, Vacaville, Solano Co. California, IV-29-93, ex sycamore, M.J. Cody collector.
23. *Stomacoccus platani*, Sacramento, Sacramento Co. California, IV-27-76, ex sycamore, R. Gill collector.
24. *Xylococcus betulae*, Rio Del, Humboldt Co. California, VII-29-81, ex *Alnus rubra*, T. Haig and R. Spadoni collectors.
25. *Xylococcus betulae*, Rio Del, Humboldt Co. California, VII-29-81, ex *Alnus rubra*, T. Haig and R. Spadoni collectors.
26. *Xylococcus macrocarpae*, Butte Co. California, III-85, ex *Libocedrus decurrens*, collector unknown.
27. *Xylococcus macrocarpae*, Grass Valley, Nevada Co. California, IV-7-91, ex *Libocedrus decurrens*, I. Foldi and R. Gill collectors.
28. *Xylococcus macrocarpae*, Grass Valley, Nevada Co. California, IV-7-91, ex *Libocedrus decurrens*, I. Foldi and R. Gill collectors.
29. *Xylococcus macrocarpae*, Grass Valley, Nevada Co. California, IV-7-91, ex *Libocedrus decurrens*, I. Foldi and R. Gill collectors.
30. *Xylococcus macrocarpae*, Sly Park, El Dorado Co. California, VI-4-81, ex *Libocedrus decurrens*, R. Gill collector.
31. *Xylococcus quercus*, Lodi, San Joaquin Co. California, VII-28-81, ex *Quercus lobata*, J. Gianelli and R. Gill collectors.
32. *Xylococcus quercus*, Lodi, San Joaquin Co. California, VII-28-81, ex *Quercus lobata*, J. Gianelli and R. Gill collectors.
33. *Xylococcus quercus*, Lodi, San Joaquin Co. California, IX-30-81, ex *Quercus lobata*, K. Brown and R. Gill collectors.
34. *Arctothezia occidentalis*, Washington, quarantine at Los Angeles, California, VI-10-83, ex shag moss, McGrath collector.
35. *Orthezia annae*, Elk Hills, Kern Co. California, IV-25-80, ex *Atriplex* sp. G. Buxton collector.
36. *Orthezia annae*, Elk Hills, Kern Co. California, IV-25-80, ex *Atriplex* sp. G. Buxton collector.
37. *Orthezia artemisiae*, Milford, Lassen Co. California, VII-10-83, ex *Artemisia tridentata*, R. Gill Collector.

38. *Orthezia artemisiae*, Milford, Lassen Co. California, VII-10-83, ex *Artemisia tridentata*, R. Gill collector.
39. *Orthezia insignis*, Hawaii, quarantine at Chico, California, XI-15-78, ex *Coleus* sp., T. Sutton collector.
40. *Orthezia newcomeri*, Sacramento, Sacramento Co. California, V-16-63, ex *Rubus* sp., M. Scribner and W. Wiard collectors.
41. *Orthezia newcomeri*, Sacramento, Sacramento Co. California, V-16-63, ex *Rubus* sp., M. Scribner and W. Wiard collectors.
42. *Orthezia sarcobati*, 1.3 mi. SE. Beatty, Nye Co. Nevada, VI-24-62, ex *Sarcobatus vermiculatus*, T. Fuller collector.
43. *Tachardiella ferrisi*, Jacumba, San Diego Co. California, III-6-83, ex *Adenostoma sparsifolium*, R. Gill collector.
44. *Tachardiella larreae*, Holtville, Imperial Co. California, I-25-72, ex *Larrea* sp., R. Flock collector.
45. *Tachardiella pustulans*, Tecopa, San Bernardino, San Bernardino Co. California, X-11-72, ex *Chrysothamnus* sp., E. Paddock et al collectors.
46. *Asterolecanium agavis*, Boron, Kern Co. California, V-18-81, ex *Yucca brevifolia*, D. Poore collector.
47. *Asterolecanium arabidis*, Visalia, Tulare Co. California, V-19-78, ex *Pittosporum tobira*, J. Akana collector.
48. *Asterolecanium arabidis*, San Martin, Santa Clara Co. California, V-4-88, ex *Ceanothus griseus*, S. O'Day collector.
49. *Asterolecanium arabidis*, Sacramento, Sacramento Co. California, I-76, ex *Pittosporum*, R. Gill collector.
50. *Asterolecanium minus*, no data available.
51. *Asterolecanium stentae*, Jamul, San Diego Co. California, X-17-88, ex *Euphorbia* sp., J. Kenyon collector.
52. *Asterolecanium variolosum*, Ross, Marin Co. California, XI-7-91, ex *Quercus kelloggii*, S. Dreistadt collector.
53. *Bambusaspid bambusae*, Redlands, San Bernardino Co. California, X-31-78, ex bamboo, Young and Vail collectors.
54. *Mycetococcus ehrhorni*, Corona, Riverside Co. California, III-30-81, ex *Quercus agrifolia*, E. Reeves and F. Harris collectors.
55. *Pollinia pollini*, Asti/Cloverdale, Sonoma Co. California, X-20-76, ex olive, R. Gill and J. Chesi collectors.
56. *Pollinia pollini*, Asti/Cloverdale, Sonoma Co. California, X-20-76, ex olive, R. Gill and J. Chesi collectors.
57. *Lecanodiaspis rufescens*, Lancaster, Kern Co. California, host unknown, A. Gilbert and D. Poore collectors.
58. *Lecanodiaspis rufescens*, Lancaster, Kern Co. California, host unknown, A. Gilbert and D. Poore collectors.
59. *Lecanodiaspis thamnasmae*, Ocotillo, Imperial Co. California, IV-27-74, ex *Thamnosma montana*, R. Flock et al collectors.
60. *Cerococcus quercus*, 5 mi. S. Banning at 4,000 ft elev., Riverside Co. California, III-15-86, ex scrub oak, R. Gill collector.
61. *Cerococcus quercus*, San Diego, San Diego Co. California, III-74, ex oak, collector unknown.
62. *Aclerda californica*, Rutherford, Napa Co. California, III-10-68, ex grass, T. Kono collector.
63. *Aclerda* sp., Ravendale, Modoc Co. California, IV-16-75, ex grass, T. Haig collector.
64. *Aclerda tokionis*, Japan, quarantine at Encinitas, California, III-3-88, ex bamboo, D. Kellum and K. Sims collectors.
65. *Allokermes branigani*, Forest Hill, Placer Co. California, VII-8-75, ex *Quercus* sp., R. Gill and J. Chesi collectors.
66. *Allokermes essigi*, Carmichael, Sacramento Co. California, V-24-78, ex *Quercus* sp., R. Harris and R. Gill collectors.
67. *Allokermes essigi*, Carmichael, Sacramento Co. California, V-24-78, ex *Quercus* sp., R. Harris and R. Gill collectors.
68. *Allokermes essigi*, Carmichael, Sacramento Co. California, V-24-78, ex *Quercus* sp., R. Harris and R. Gill collectors.
69. *Allokermes essigi*, Santa Paula Canyon, Ventura Co. California, VIII-14-75, ex *Quercus agrifolia*, R. Hobza and R. Gill collectors.
70. *Allokermes ferrisi*, Mid Valley Reservoir, Santa Catalina Island, Los Angeles Co. California, V-30-81, ex *Quercus dumosa*, J. Johnson and R. Gill collectors.
71. "*Eriococcus gillettei*," Del Puerto Canyon, Stanislaus Co. California, IV-7-80, *Juniperus* sp., R. Gill collector.
72. *Kermes nudum*, Earthquake Fault, Mammoth Lakes, Mono Co. California, VII-4-76, ex *Castenopsis sempervirens*, R. and R. Gill collector.
73. *Kermes rimarum*, Central Point, Jackson Co. Oregon, V-26-77, ex *Quercus garryana*, R. Penrose collector.
74. *Kermes shastensis*, Shasta Springs, Siskiyou Co. California, V-19-76, ex *Quercus chrysolepis*, R. Gill collector.
75. *Dactylopius confusus*, Westgard Pass, Inyo Co.

- California, IV-91, ex. beavertail cactus, R. Gill and I. Foldi collector.
76. *Dactylopius confusus*, Westgard Pass, Inyo Co. California, IV-91, ex. beavertail cactus, R. Gill and I. Foldi collector.
77. *Dactylopius opuntiae*, Santa Cruz Island, Santa Barbara Co. California, V-20-79, ex *Opuntia*, R. Gill collector.
78. *Dactylopius tomentosus*, Chico, Butte Co. California, IX-5-78, ex cactus, Sutton and Adams collectors.
79. *Dactylopius tomentosus*, Chico, Butte Co., California, IX-5-78, ex cactus, Sutton and Adams collectors.
80. *Acanthococcus adenostomae*, 10 mi. SE. Middletown, Lake Co. California, IV-3-81, ex *Adenostoma fasciculatum*, A. Hardy collector.
81. *Acanthococcus araucariae*, Berkeley, Alameda Co. California, VIII-72, ex *Araucaria* sp., C. Koehler collector.
82. *Acanthococcus araucariae*, Berkeley, Alameda Co. California, VIII-72, ex *Araucaria* sp., C. Koehler collector.
83. *Acanthococcus azaleae*, Placerville, El Dorado Co. California, V-4-83, ex *Azalea* sp., Stewart and Shutta collectors.
84. *Acanthococcus azaleae*, Placerville, El Dorado Co. California, V-4-83, ex *Azalea* sp., Stewart and Shutta collectors.
85. "*Eriococcus*" *borealis*, Del Puerto Canyon, Stanislaus Co. California, IV-7-80, ex *Salix* sp., R. Gill et al collectors.
86. "*Eriococcus*" *borealis*, Del Puerto Canyon, Stanislaus Co. California, IV-7-80, ex *Salix* sp., R. Gill et al collectors.
87. *Acanthococcus coccineus*, Shingle Springs, El Dorado Co. California, XI-30-83, ex cactus, M. Shutta collector.
88. *Acanthococcus coccineus*, Stockton, San Joaquin Co. California, VIII-7-77, ex cactus, K. Brown collector.
89. *Acanthococcus cryptus*, Portal, Cochise Co. Arizona, IX-16-86, ex *Gutierrezia microcephala*, Backus collector.
90. *Acanthococcus diaboli*, 2 mi S. Fish Slough, Inyo Co. California, IV-15-81, ex grass, R. Gill collector.
91. *Acanthococcus diaboli*, 2 mi S. Fish Slough, Inyo Co. California, IV-15-81, ex grass, R. Gill collector.
92. *Acanthococcus dubius*, Fish Slough, Mono Co. California, VIII-29-87, ex *Chrysothamnus* sp., R. Gill collector.
93. *Acanthococcus dubius*, Fish Slough, Mono Co. California, VIII-29-87, ex *Chrysothamnus* sp., R. Gill collector.
94. *Acanthococcus epacrotrichus*, Pleasant Valley Creek, Alpine Co. California, VIII-10-82, ex *Artemisia tridentata*, R. Gill collector.
95. *Acanthococcus epacrotrichus*, Pleasant Valley Creek, Alpine Co. California, 8-10-82, ex *Artemisia tridentata*, R. Gill collector.
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97. *Acanthococcus eriogoni*, Quarantine From Texas at Riverside, California, VI-13-80, ex cactus, E. Storm collector.
98. *Acanthococcus quercus*, 3 mi. NE. Auberry, Fresno Co. California, IV-24-81, ex oak, N. Smith and R. Gill collectors.
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101. *Gossyparia spurius*, no other data, III-67.
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103. *Gossyparia spurius*, Rancho Cordova, Sacramento Co. California, V-6-81, ex elm, R. Gill collector.
104. *Gossyparia spurius*, Rancho Cordova, Sacramento Co. California, V-6-81, ex elm, R. Gill collector.
105. *Oregmomyza eriogoni*, 5 mi. S. Banning, Riverside Co. California, IV-20-91, ex *Eriogonum fasciculatum*, I. Foldi & R. Gill collectors.
106. *Oregmomyza neglecta*, Quatal Canyon, Ventura Co. California, V-24-77, ex *Atriplex*, R. Hobza and R. Gill collectors.
107. *Ovaticoccus agavium*, Yucca Valley, San Bernardino Co. California, XI-16-81, ex *Agave* sp., J. Lounsbury collector.
108. *Phoenicococcus marlatti*, Marina del Rey, Los Angeles Co. California, I-3-80, ex *Phoenix* sp., J. Humphrey collector.

COLLECTION AND PRESERVATION TECHNIQUES

The common method of collecting scale insects is to place them in alcohol in the field. The California Department of Food and Agriculture uses 70% isopropyl alcohol for this purpose. However, some scales do not preserve well in alcohol and become very difficult or impossible to clear properly. They are best collected by removing an infested part of the host, which is then allowed to dry naturally. Steps should be taken to suppress mold growth.

In order to be preserved and identified properly, scale insects must be cleared completely by removing the internal body contents, leaving only the exo-skeleton and appendages intact. Specimens are then stained and placed on microscope slides for study under high magnifications. All of the slide mounted specimens used in producing the morphological illustrations used in this book are preserved in Canada balsam. Balsam is the current standard permanent mounting medium for scale insects. Euparal is another acceptable permanent medium. Temporary media such as Hoyer's or polyvinyl alcohol (PVA) are also used for less important specimens or when rapid determinations are required, but these media cannot be considered permanent.

Specimens should be cleared first in potassium hydroxide (10%) or a combination of potassium hydroxide and Essig's aphid fluid (20 parts 85% lactic acid; 2 parts liquified phenol; 4 parts glacial acetic acid; 1 part distilled water). The specimens are usually stained with either acid fuchsin, lignin pink or a combination of the two. The following clearing-staining procedure is currently used for scale insects in the California Department of Food and Agriculture Homoptera Laboratory. The procedure has been developed and modified over the years by numerous individuals including Harold Morrison, Richard Wilkey, Tokuwo Kono and the author. The procedure is not a rigid one and is often modified to suit conditions.

SLIDE MOUNTING PROCEDURE FOR SCALE INSECTS

1. Prepare several small tools from stainless steel insect pins by bending and flattening the ends at various angles to form spatulas. The spatula shapes allow easy pumping of the scale to remove the liquified body contents and allow easy transferring of the specimens from one reagent to another.
2. If not already in alcohol, remove specimens gently from the host substrate and place in clean 70% isopropyl alcohol. (Alcohol is necessary here because the body waxes of the soft scales would cause them to float in the surface tension of plain water.) Make a small midlateral incision on one side of the scale body. Remove immediately to potassium hydroxide (KOH).
3. Soak specimens in cold 10% KOH for 1 to 24 hours. **DO NOT HEAT**. Specimens may be pumped and teased lightly during this step to aid in the clearing process. Fresh specimens are usually cleared adequately in 1 to 2 hours, but a 24 hour time period may give better results in some cases.
4. Remove to isopropyl alcohol acidified with a 10% solution of hydrochloric acid to aid in neutralizing the KOH. Let stand for 15 minutes to 24 hours.
5. Place in Essig's aphid fluid (EAF) containing several drops of the preferred staining agent. Let stand for 10-15 minutes to further neutralize the KOH. Heat at 50° C. for 1 to 24 hours. Move to clean, new, unstained EAF. Tease and pump specimens until as clear as possible. Re-heat for 1 hour if necessary.
6. Place specimens in cellosolve (ethylene glycol monoethyl ether) for removal of all of the EAF and for dehydration of the specimens prior to placing in balsam.
7. Place specimens in tetrahydrofuran (THF), a wax solvent, for five minutes if necessary.
8. Place specimens in a drop of balsam on a microscope slide and add a cover glass.

PHOTOGRAPHIC TECHNIQUES

The color photographs included in this volume were produced primarily by the author. However, George Buxton supplied a number of the pictures of specimens collected prior to 1972. Those pictures were produced with

standard 35 mm format single lens reflex cameras with close up lenses and bellows attachments.

Most of the author's pictures were produced in a different manner. The pictures were taken through a Wild M-5 stereo microscope with a Zeiss C-35 camera attachment. Illumination was by electronic strobe. Film is Kodachrome 25 color slide film. Magnifications of the author's photographs range from 1.5X to 12X magnification on the 35 by 24 mm film plane. The pictures were then enlarged to the 65 by 54 mm format used in this volume.

ILLUSTRATION AND PAGE LAYOUT TECHNIQUES

Morphological illustrations were drawn from actual slide mounted specimens. Specimens were chosen which had at least one half of the body intact and generally not noticeably distorted. The specimen slide was placed on a Bausch and Lomb bioscope slide projector. The image of the specimen was then projected onto the drawing surface. Magnifications varied with each specimen and are not to scale since each illustration had to fit a certain page size. Scale insect body shapes and sizes can change so drastically in relation to other constant sclerotized body structures as legs and mouth parts that proportional scaling is not possible. Each full size drawing contains the ventral aspect on the right side and the dorsal aspect on the left.

Most of the illustrations for this volume were produced by conventional means using pen and ink. However, the illustrations in Figures 12, 40, 48-51, 54, 57, 70 and 74 were created in a new and different way. Each original sketch was electronically scanned into a computer via a flat-bed scanner. The resulting electronic image was then used as a template in a computer software program to electronically draw and type-set the image. Figures 1-11 and 13-17 were pen and ink originals which were scanned electronically and the templates were then used to type-set the names of the morphological structures involved. The text was then printed on clear film which was used as an overlay on the the drawing to produce the camera ready stat photograph. The typesetting and layout were produced by the author on a computer using typesetting software. Printing was done by the State Printing Plant.



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